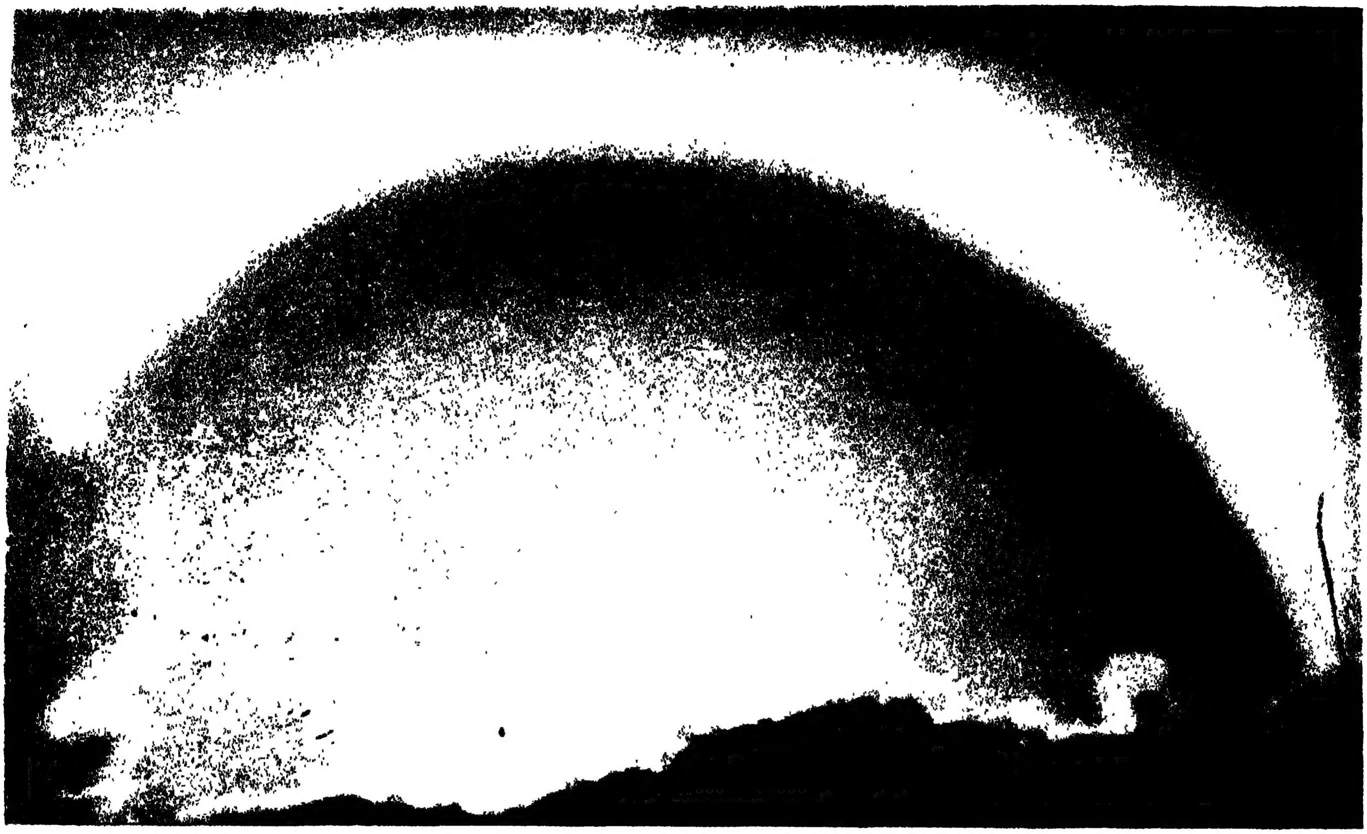
THE DAILY MIRACLE OF THE RAINBOW'S HUES



Royal Meteorological Society

A wonder that has been renewed millions upon millions of times since Earth first acquired an atmosphere, and one that has puzzled man from the earliest ages, is that of the rainbow (lower picture). How sunlight is refracted and reflected by raindrops to produce this coloured band of light is explained in page 20. Double bows like those illustrated here are seen only when the sunlight is very strong. By the same principles of refraction and reflection, ice crystals or particles of dust in the upper air cause the solar halo (upper picture), a whitish or faintly coloured ring at some distance round the sun

THE

WORLD OF WONDER

10,000 THINGS
Every Child Should Know

Edited by

CHARLES RAY

VOLUME ONE

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INTRODUCTION

THIS book describes in word and picture the world of wonder in which we live and the universe of which our world is a tiny part. It has been so planned that by means of simple description and explanatory drawing it makes clear a vast variety of things that might otherwise seem too difficult to understand. It explains the why and wherefore of such familiar phenomena as the thunderstorm, the rainbow, the daily tides at the seaside, the greasy ring round the Moon, the regular succession of day and night, the procession of the seasons, and a thousand other things that are known to all but understood by few.

It explains how man has tamed the powers of nature, and how the many marvellous machines which he has invented are made to work. From the simple lever and screw and wheel we are led on to such complicated devices as a modern printing press, a turbine steamer, a Diesel engine, an atomic pile, a radar transmitter and receiver, and a jet-propelled airliner, and are shown their operations in such a way that we are able to understand exactly how they work.

We see by means of photograph and explanatory drawing the marvels of the plant and animal world, the wonders of fertilisation and reproduction, with the miracle of life and its activities, the working of the muscles and nerves and blood vessels, and the complicated operations of sight and hearing and taste and smell and touch.

The marvels of geography and geology are explained in new and striking ways, and such mysteries as how the Sun keeps Niagara Falls flowing, what causes the earthquake and the volcanic eruption, why some beaches are sandy and others shingly, why the wind is sometimes a friend and sometimes a foe, and other similar problems, are all made simple and intelligible to the reader who may know nothing at all about science.

But the book has been planned to do more than explain the familiar. It helps us by simile and picture to understand those strange mysteries of modern science which have only become known during the past few years and have changed the whole outlook of scholars. Difficult things like Mendelism, Relativity, the structure of the atom, the mysteries of time and space, and the conception of the stars and nebulae, are all explained in such a way that any intelligent boy or girl can have some idea of what they mean.

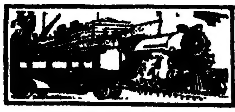
Sound broadcasting, television, the talking cinema, and the gramophone are now commonplaces of our lives. But how many of us know exactly the way in which these things work? How does radio bring the broadcast concert or the pictures of a queen's coronation to our home? How is the gramophone record made and the sound reproduced in a room? This book, by its wonderful and carefully worked out picture diagrams, makes such matters simple and clear to all.

It is the remarkable series of explanatory drawings by Mr. L. G. Goodwin that makes the book the unique work it is. No other artist has such a facility in explaining the difficult and the complicated, and for several years Mr. Goodwin worked exclusively in preparing drawings for this book. His work speaks for itself. The most intricate operations and activities of man and nature are, by the picture diagrams, made clear and understandable.

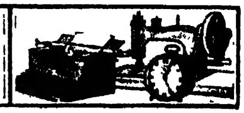
But the book is not only a work of popular science: it tells, in absorbing narrative form, the story of British life and history, and we see, passing vividly across the stage of time, such notable figures as William the Conqueror, Richard the Lion-Hearted, William Shakespeare, Sir Francis Drake, Guy Fawkes, Bonnie Prince Charlie, and scores of others, who all played a prominent part in the drama of life.

The great index at the end of the book helps us to find quickly anything we want to know, and an elaborate system of cross-reference in the index and throughout the book links up the different chapters and pictures dealing with allied subjects. The book is intended to bring the whole universe within the understanding of every boy and girl.

CHARLES RAY.



MARVELS of MACHINERY



THE VERY FIRST OF ALL MACHINES

The simplest of all machines is the lever, and it was probably the one that man invented first. Without the lever we should practically be at a standstill, for in various forms it comes into most of the machinery that we use, whether the machine be a simple apparatus such as a door-key, or a pair of scissors, or whether it be a complicated machine such as is used for printing this book Here we read about the different kinds of levers

COMPARED with many animals, such as the elephant, the horse, the ox, the gorilla, the lion and the tiger, man is a very weak creature, but what he lacks in physical strength he makes up in mental ability.

Man is the only animal in the world that makes a tool to assist him in his work Starting from the very simplest form of tool he has developed the idea till now he makes the most complicated machines which are practically robots, or mechanical men, and once set going do the work of many men with scarcely any human attention at all.

We are staggered when we see the almost uncanny operations of, say, a printing machine or a boot-making machine; yet the beginnings of machinery were simple in the extreme.

The First Machine

Probably the very first machine or tool that a man ever used was the lever Something had to be moved, a big stone, perhaps, shifted out of the way, and this stone was too heavy for the man to move. In some moment of inspiration or by a lucky chance he took the bough of a tree and placing it under the stone prised it along till he moved it from his path. Without knowing it, this prehistoric man had invented the first machine. He had discovered the principle of the lever.

We must remember that while much of the machinery used to-day is very complicated in design, a machine can really be exceedingly simple, for all the term means is a device to lighten the labour of man, or something to give him more efficiency in his work.

The lever is therefore really a machine. It consists of a rigid rod or bar resting on a fixed point or edge, and capable of turning freely about that point.

The bar may be straight or curved, and the principle on which the lever works is quite easy to understand.

Let us think of a balance or a pair of scales In its simple form we have an arm resting on a pivot, and at the end of each arm is a pan. The arm being supported in the middle, and the pans being of equal weight, the whole thing balances perfectly.

Now we put some object to be weighed in one pan, say, a packet of sugar. The force of gravity pulls this down, but by putting the necessary weights in the other pan we can make the arm of the balance once again horizontal. In each pan there is a weight, in one case a pound of sugar, in the other case a pound of metal. These acted upon by gravity become forces pressing down the balance on each side. When the forces are not exactly equal one side or the other tips down, and the other side tips up. The balance is a lever. The pivot on which the arm is supported is called the fulcrum, a word which simply means a support.

Now let us look at another simple form of lever. Take a children's see-saw. A plank rests on a post or log or stone, and the place where it is supported is the fulcrum. Children sit at each end and by alternately giving the ground a push with their feet send the ends up and down in their turn. If the children are of equal weight the plank, like the arm of the scale, has to be supported in the middle, but if one child is heavier than the other, then the plank must be pushed along so that the end on which the lighter child sits is farther from the fulcrum than the end on which the heavier child rests.

A BOY MOVES THE WORLD

Archimedes once said "Give me a lever long enough and a prop strong enough and with my own weight I will lift the world." In theory it is true that even a boy could lift the world in this way, though actually he would have to move with the speed of a cannon ball for millions of years to alter the Earth's position by a fraction of an inch.

Man's Friend

This helps us to understand the value of the lever as a machine for lightening the work of man. The real principle of the lever is this: that a small force acting on a long arm can balance a much larger force or weight acting on a short arm.

In referring to a lever we generally speak of the force exerted at one end of the arm as "the power," and the body lifted or the resistance offered at the other end as "the weight." There are thus in every lever, whatever its form, the three parts—the power, the weight, and the fulcrum.

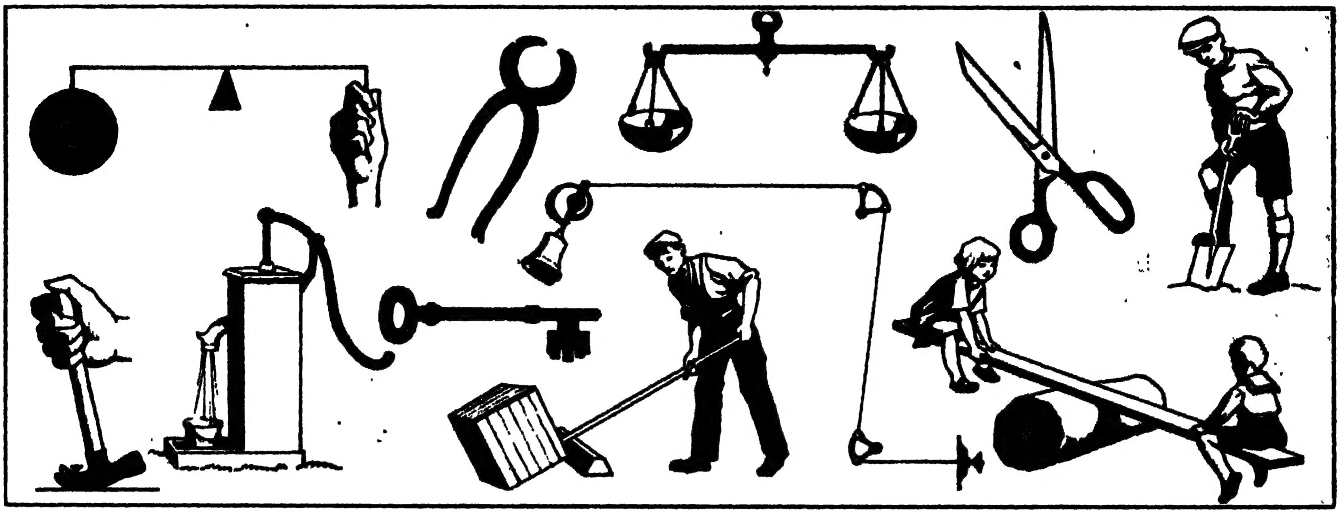
In many levers, such as the balance and the see-saw, the power or force exerted is at one end, the weight or resistance at the other end, and the fulcrum in the middle. This applies to single levers such as the see-saw, or double levers such as the pincers and scissors, and all levers in which the three parts are in this order are known as

levers of the first class, type or order.

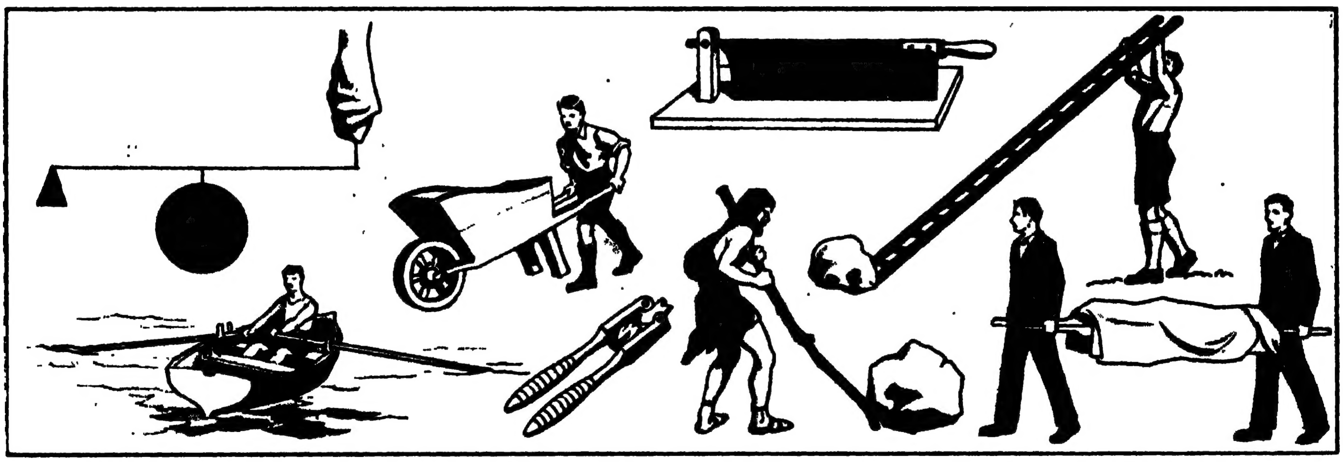
But sometimes the fulcrum is at one end and the weight or resistance in the middle, when the power is necessarily at the other end of the arm. In such a case we describe the lever as a lever of the second order. We get examples of this in a wheelbarrow, the wheel being the fulcrum, the barrow the weight, and the man's arms pushing it the power. We get it also in the case of rowing, the oar-blade in the water being the fulcrum, the boat with all that is in it the weight, and the man's hand pulling the handle of the oar the power. In nutcrackers we have an example of a double lever.

But there is still another kind of lever, known as a lever of the third order. In this the fulcrum is still at the end, but the weight is at the other end and the power in the middle. The human arm is an example of this. The hand holding something is the weight, the elbow joint is the fulcrum, and the muscle attached to the radius bone is the power.

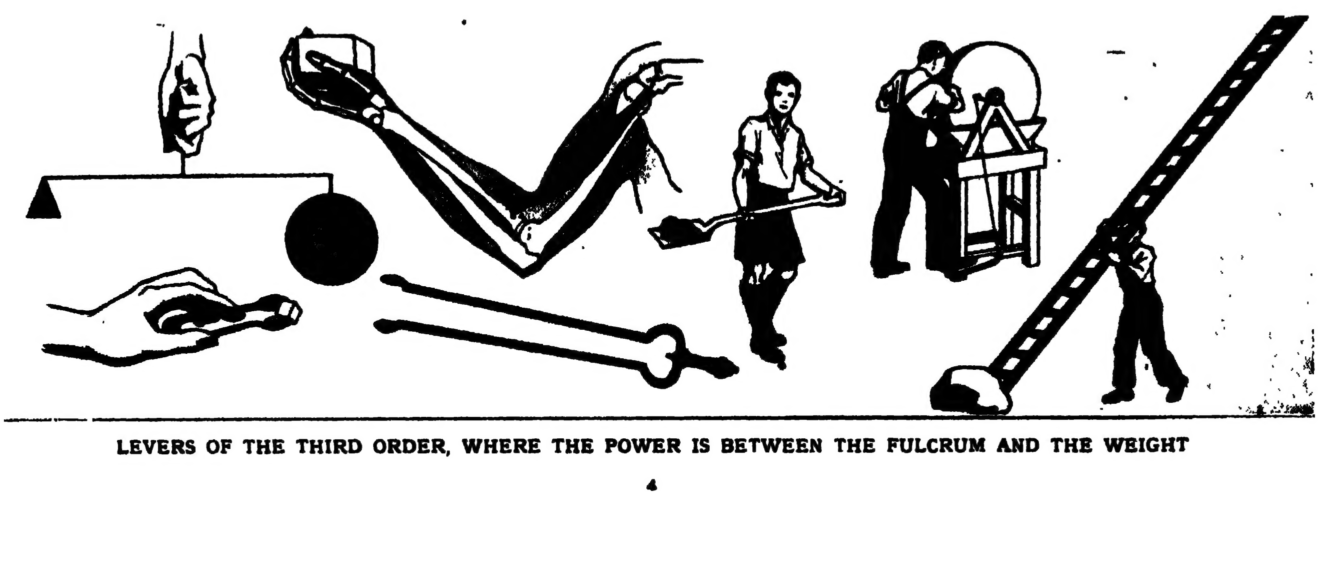
It is interesting to note that in carrying out an operation with a lever we



LEVERS OF THE FIRST ORDER, IN WHICH THE FULCRUM IS BETWEEN THE WEIGHT AND THE POWER MOVING IT



EXAMPLES OF LEVERS OF THE SECOND ORDER, WHERE THE WEIGHT IS BETWEEN THE FULCRUM AND THE POWER



LEVERS OF THE THIRD ORDER, WHERE THE POWER IS BETWEEN THE FULCRUM AND THE WEIGHT

sometimes change the same apparatus from a lever of one order to that of another. For instance, a man wants to raise a ladder from the ground against a wall or stone; the wall or stone becomes the fulcrum, the ladder itself is the weight as well as the arm, and the man's hands are the power.

When the man begins to raise the ladder he takes hold of the end, and in that case the weight is all between the fulcrum and the power, so that the lever is one of the second order. But when, after a time, the man works his hands down so that the bulk of the ladder is above his hands, then we have a lever of the third order, for the man's hands or power are between the fulcrum and the upper end of the ladder, which is the weight.

All orders of lever may be single, double, bent, or curved.

It is interesting, knowing the principle of the lever, to think out examples in every-day life where it is used. Without the lever, indeed, we could have no machinery. It is used in the railway engine, the motor-car, the moving bridge, the mechanical excavator, the printing machine, the sewing machine, the crane, the mechanical digger, and a thousand other devices which make our civilisation what it is.

As we read in another part of this book, the crank and axle and the pulley, so valuable as aids to man in doing his work, are only forms of the lever.

This huge mechanical shovel is a remarkable example of how the principle of the lever is used in industry. The shovel itself is a lever of the third order, the lever which the man is holding is one of the second order, while the steel cables passing over the pulleys at the top of the arm form a lever of the first order.

The great value of the lever is that by its aid a small force is able to overcome a very great resistance, and a light body move a very heavy weight.

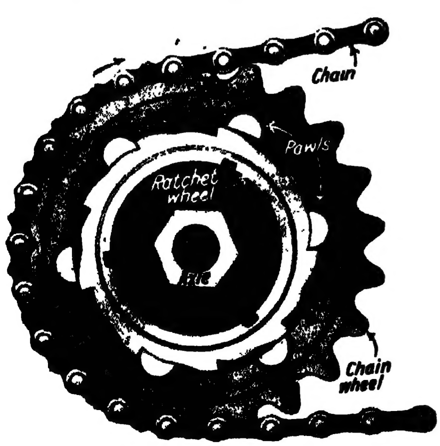
We must remember that a machine cannot do any work of itself. All it can do is to transmit the work that is put into it. This seems puzzling at first thought, for when you see a small boy moving a very heavy stone with a long crowbar it looks as though the machine itself were doing more work than the boy is putting into it. He could not lift the heavy stone by himself, and yet he can do it with the aid of the crowbar.

The principle of the lever is expressed in this way: that the force on one side of the fulcrum, multiplied by its distance from the fulcrum is equal to the force on the other side, multiplied by its distance from the fulcrum. Therefore, if a boy weighing 100 lb. takes a crow bar six feet long he can, if he has his fulcrum one foot from the end, move a stone weighing 500 lb. or thereabouts. Of course, a certain amount of power is lost by friction.

In a see-saw a man sitting close to the fulcrum does not go up and down very much, but a child balanced at the other end of the beam, far from the fulcrum, will go up and down much faster and farther than the man. Thus, if a man weighing 140 lb. sits 4 ft. from the fulcrum, he can balance a child weighing 70 lb. sitting 8 ft. from the fulcrum, and make that child go up and down through a considerable distance and at a very much faster rate than he himself is moving.

THE SECRET OF THE FREE WHEEL

All cyclists know the advantage of having a free wheel, but there are many people who do not understand exactly how this device works. The picture here will show the principle of the free wheel, which is always attached to the back or driving wheel of a bicycle. In the picture the free wheel is shown as if the bicycle were moving to the right.



The inside of a free wheel

Attached to the hub of the free wheel is a ratchet wheel round which turns the chain wheel. Between the chain wheel and the ratchet wheel are a number of crescent-shaped pawls moving loosely in semi-circular grooves.

When the pedals are turned to propel the cycle three of the six pawls engage with notches and projections in the ratchet wheel, and are there held in position by the chain wheel pressing on them.

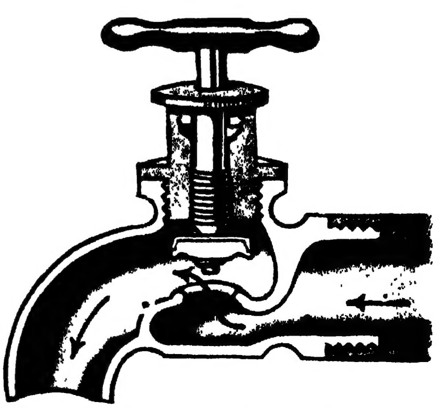
Meanwhile the other three pawls are pressed up into their grooves, and so do not engage with the projections in the ratchet wheel which pass over them as the wheel turns round. By having more notches and projections on the ratchet wheel than there are pawls much wear and tear is saved, as only three pawls are in use at once.

As soon as the rider ceases to pedal the chain wheel stops going round, but the ratchet wheel continues to revolve, and as it does so it pushes the pawls up into their semi-circular grooves, and the projections or ratchets pass over them without hindrance. In this way the axle of the bicycle's back wheel with the ratchet wheel on it can go on turning, while the chain wheel remains stationary.

As soon as the cyclist begins pedalling again the chain turns and the projections engage once more with the pawls. By having more projections than pawls the engagement is made without delay.

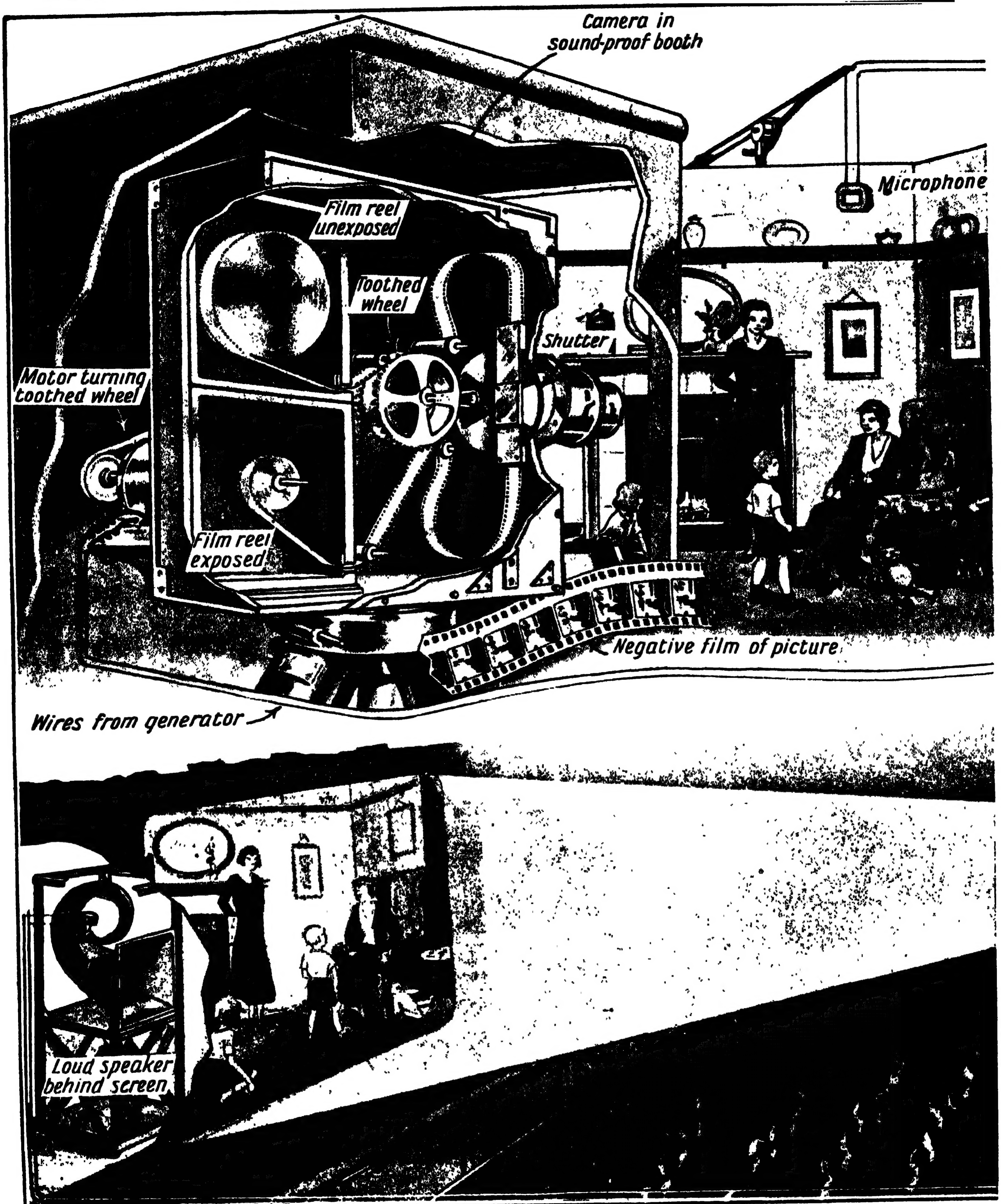
THE INSIDE OF A WATER-TAP

We all know how in the ordinary household tap we make the water come gradually by turning the cock round and round. This picture showing the inside of a tap makes it clear why the water comes slowly at first and then faster. As we unscrew the cock the valve is raised more and more and thus the opening through which the water flows becomes gradually larger



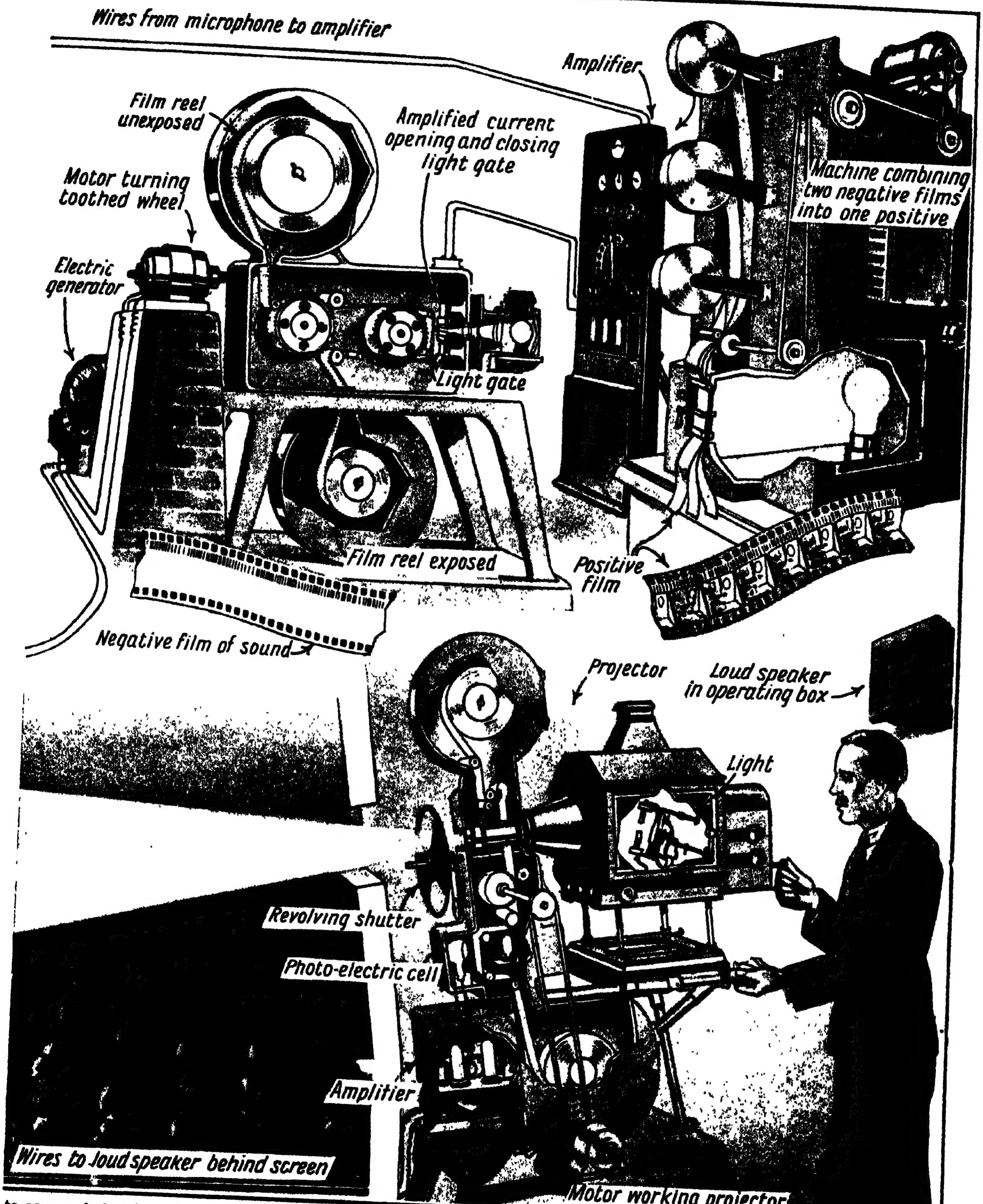
How the water flows from the tap

HOW A SOUND PICTURE IS TAKEN AND



In these pages and on page 8 we see how a talking picture is made and reproduced. Thousands of pictures of a scene, each a little different from the one before, are photographed on a film, the film being passed before the camera lens at a regular speed by electric motor. At the same time the sounds of the scene are picked up in a microphone, where the sound waves carried by the air vibrate a diaphragm and so move carbon granules through which an electric current is passing. This movement causes the current to fluctuate, and thus the sounds are transformed into a varying electric current The current passes through an amplifier, where it is regulated to the necessary strength, and the wires are connected with a light gate in the sound-recording apparatus. The light gate consists of a slit through which a beam of light passes, and is focused on to the edge of a film. The fluctuations of the current the slit

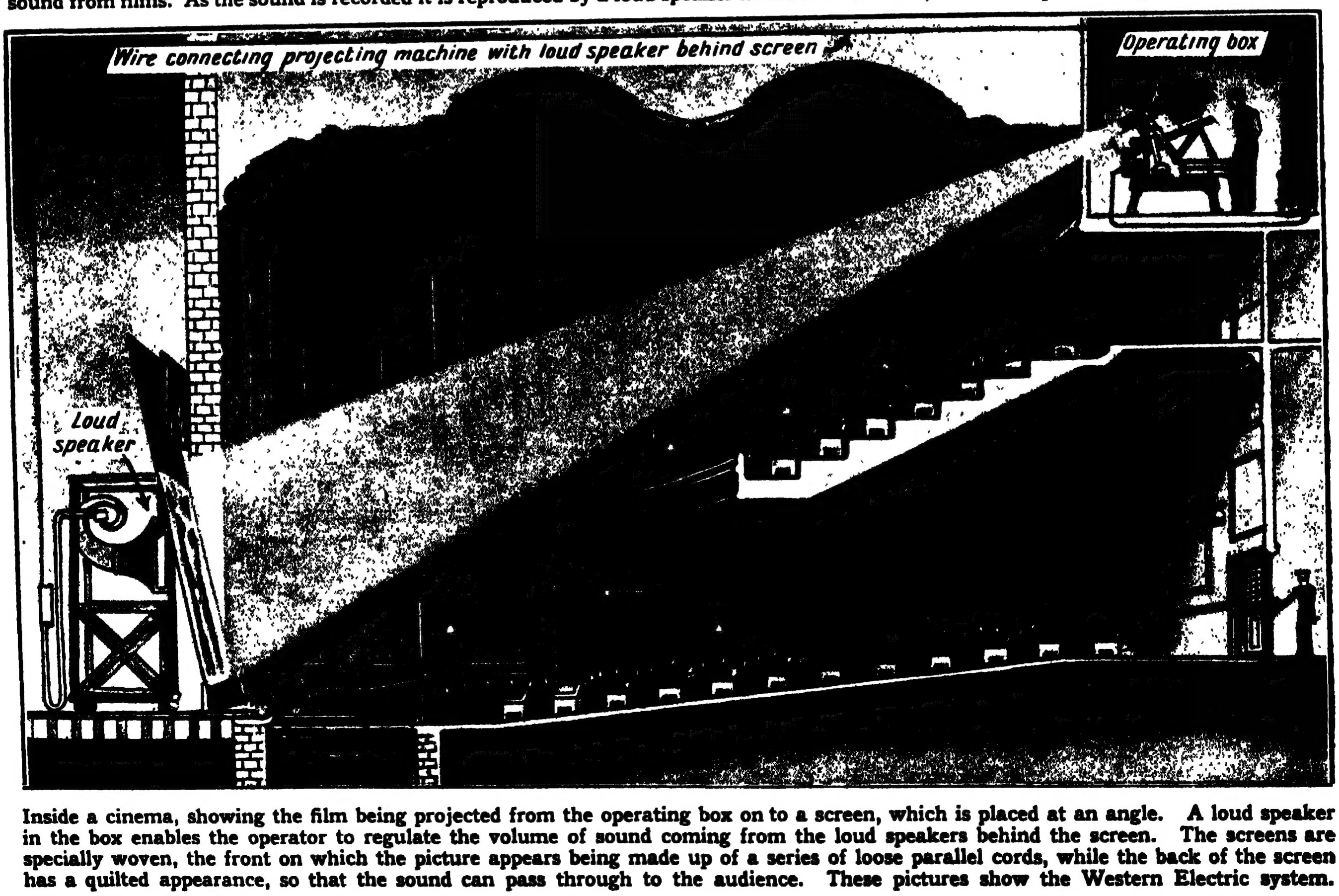
BOTH SEEN AND HEARD IN THE CINEMA



to open and close in such a way as to vary the width through which the light passes. The result is the reproduction on the film of
lines of varying density. From the two negative films a single positive film containing both picture and sound record is made. At the
cinema the film is run through a projector, about ninety feet of film passing before the lens each minute. Each picture is stationary
for a moment, being cut off from others by a rapidly revolving shutter. It is the rapid succession of pictures thrown on the screen
that gives the illusion of movement. As the film runs through the projector a beam of light travels through the sound track on the
edge of the film and is focused on a photo-electric cell, which transforms the varying light intensities into electric fluctuations. These
are amplified and carried by wires to loud speakers, where they are transformed into sound. The system shown is the Western Electric.

THE TALKING PICTURE IN STUDIO & CINEMA

Here is a view of the recording studio. The microphone can be moved about. The sound, transformed into electric current, is carried by wires to a control room, and thence to amplifiers, from which it passes to the machines where the sound film is made. Sometimes the sound is passed to a machine where gramophone records are made for use with cinema projectors that cannot reproduce sound from films. As the sound is recorded it is reproduced by a loud speaker in the control room, where an operator regulates the volume.



Inside a cinema, showing the film being projected from the operating box on to a screen, which is placed at an angle. A loud speaker in the box enables the operator to regulate the volume of sound coming from the loud speakers behind the screen. The screens are specially woven, the front on which the picture appears being made up of a series of loose parallel cords, while the back of the screen has a quilted appearance, so that the sound can pass through to the audience. These pictures show the Western Electric system.

WHY WILD ANIMALS ARE FIERCE

We all know that while the domestic animals, such as the dog, the cat, the horse, the sheep, and the cow, are in most cases quiet and gentle, the wild animals are generally fierce and dangerous, though they are not so fierce in a zoo as they are in the jungle or forest. Why is this? There are several reasons, and here we are told something about the cause of this fierceness

It is doubtful if anything causes so much trouble in the world as fear. It is fear that makes the nations arm against one another. It is generally fear that makes them go to war. It is fear of losing their money or their jobs or their health or something of that kind that makes the majority of people miserable. If we could do away with fear we should, without the slightest doubt, do away with most of the unhappiness that exists among human beings.

And what is true of human beings is also true of animals. Generally speaking, it is fear that makes them snarl and bark and bite and fight. A lion or a tiger meets a man and it puckers up its nose, shows its teeth, growls and springs upon him. It is not so much that it wants to kill the man for killing's sake, as that it fears him and springs upon the man to destroy him before he can do it any injury.

Everywhere in the world we find this fear showing itself in fierce actions. Soldiers being trained in bayonet fighting are encouraged to look fierce and determined and to shout savagely in order to frighten the enemy. Boxers when engaged in a match often do the same thing to unnerve their opponents. It is astonishing how much alike human beings and animals are in their behaviour and actions, except where education and religion have raised man above the beast.

Of course, another reason for the fierceness of the wild animals is the everlasting struggle for food. When domesticated or confined in zoos, the animals become much gentler, and this is partly because the fear of hunger is removed from them. Their food is supplied at regular intervals, and so the great struggle for existence disappears.

But in the wild there is a contest for food supplies, and animals not only become fierce in order that they may capture their prey, but in order that they may protect it, when it is captured, from being stolen by other animals.

Even animals that are gentle in the ordinary way will do what seem cruel things even to their own kind when they are alarmed. Thus rabbits and guinea pigs and white mice often devour their young if they are in fear.

An old writer speaks of the time when the wolf shall dwell with the lamb, and the leopard shall lie down with the kid, and the calf and the young lion and the fatling together, and a little child shall lead them. If that time comes it will certainly be an era of glorious peace, as the prophets have foretold, for fear will have been removed not only from men, but from the animals, and there will be plenty of food for all. For it is fear of starvation that has usually driven tribes and nations and also wild beasts to invade each other's territories

A LION SNARLS BECAUSE FEAR CAUSES ANGER

A TIGER SHOWING FEAR OF THE PHOTOGRAPHER

THE AEROPLANE FLEET OF THE PLANT WORLD

THE seeds of plants are scattered about by nature in all sorts of ways. Some are shot to a distance from the plant by a miniature explosion; some have hooks and are dispersed by catching in the coats of animals that pass by; and others again form a sort of natural aeroplane and are carried about by the wind.

It is very interesting to examine the various devices which the plants have evolved to enable the wind to carry them. Sometimes there are tufts of silky hair, as in the willows and poplars. Sometimes there are plumes as in the dandelion, spear thistle, groundsel, coltsfoot, valerian, bulrush, and other plants. In some cases, as in the clematis and mountain avens, the plume develops into a long thin feather. In the case of other plants there are thin wings to catch the wind, as in the sycamore, the ash, the birch, the elm, and the maple. The wings are generally so adjusted as to make the seed's descent slow with a spinning motion.

Some small seeds that are very light indeed do not need parachutes or wings, and are blown hither and thither by the wind, just as the dust is blown.

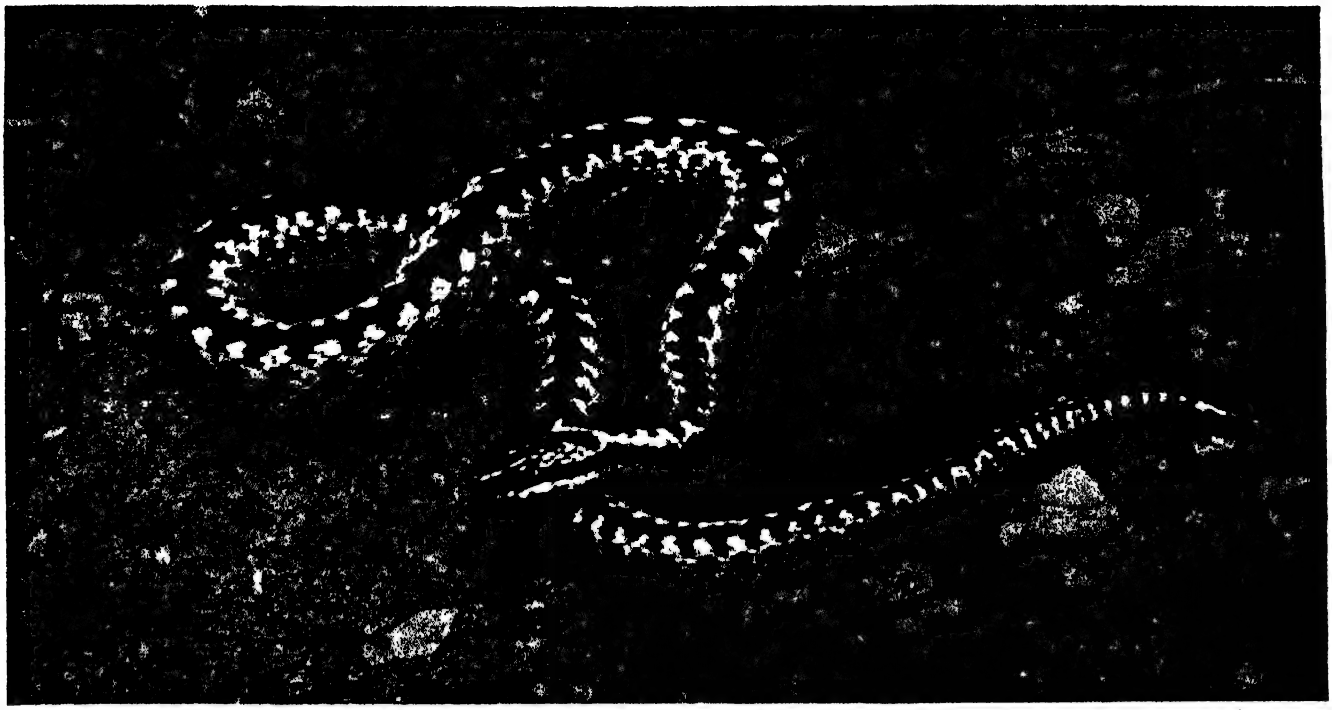
The seeds that are dispersed by the wind are generally quite small, and the flying devices which they bear are very large in proportion to their size and weight. Those plants that have a tuft or plume of hairs are very buoyant, and are able to catch the slightest breeze. Such seeds are often carried to very great distances from their parent plants, and are usually widely distributed over the Earth.

It is always an interesting recreation in late summer and autumn to look out for the different seeds of the countryside which are dispersed by the wind's action

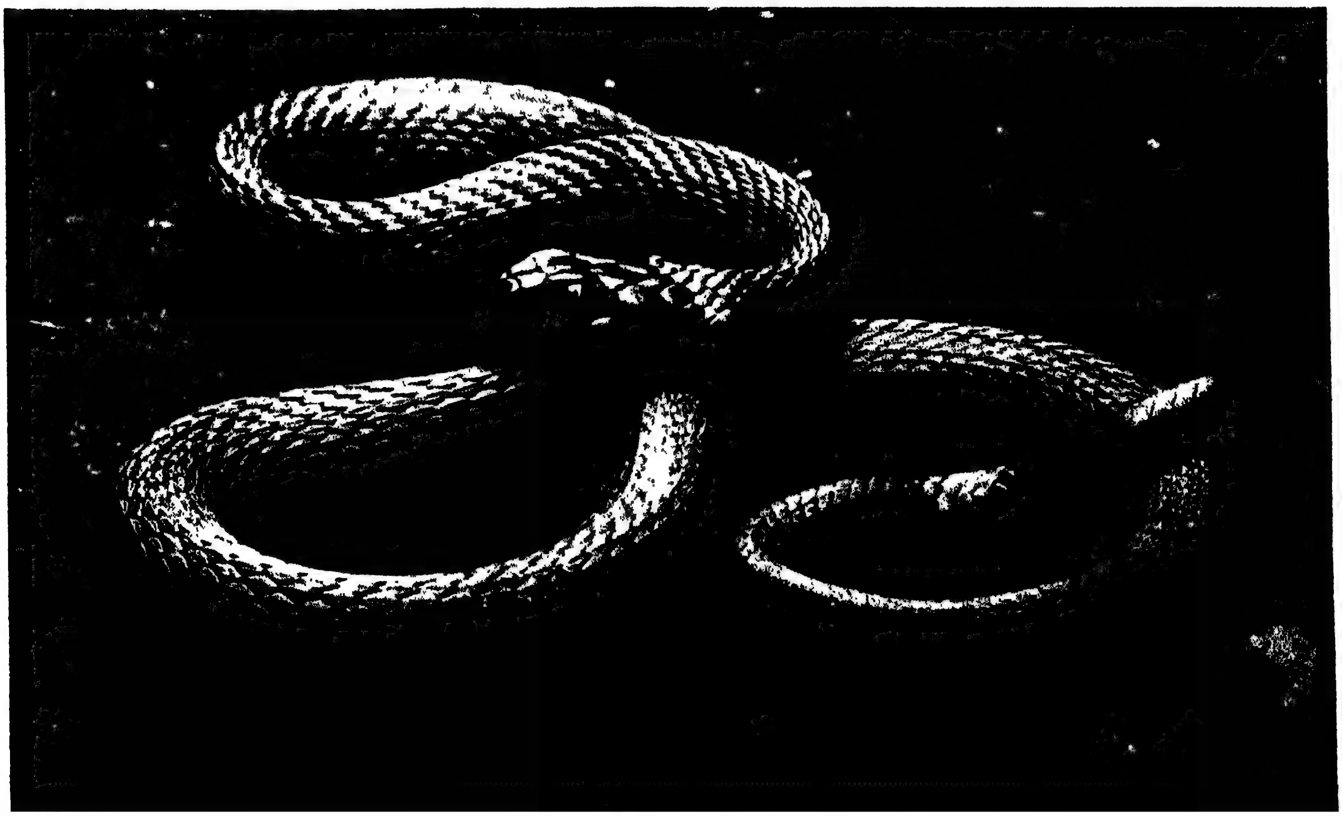
SEEDS WITH WINGS OR PARACHUTES THAT ENABLE THEM TO TRAVEL IN THE WIND

1. Dandelion. 2. Ailanthus. 3. Quaking grass. 4. Lime. 5. Heliosperma. 6. Epilobe. 7. Camphor tree. 8. Dioscorea. 9. Aeschynomene. 10. Megacarpaea. 11 Reed mace 12. Opoponax. 13. Adenium. 14. Elm. 15. Polygonum. 16. Groundsel. 17. Artedia. 18. Thrift. 19 Maple. 20 Scabious 21 Valerian. 22. Banisteria. 23. Triopteris. 24. Mountain avens 25. Gyrocarpus 26. Hop 27. Willow herb

HARMFUL AND HARMLESS BRITISH SNAKES



There is only one venomous species of snake in Great Britain, and that is the Adder or Viper. We can distinguish it by the dark zig-zag line down its back and by the V-like mark on its head. It is quite common all over England and Wales, and is found in Scotland, but not in Ireland. Unlike its harmless relative, the Grass Snake, it is not fond of water, and is generally found in dry woods and on sandy banks. One should always be careful when sitting down on a fallen tree trunk that a viper is not hiding in some crevice. The viper varies in colour, from dark brown to a light reddish. It feeds on field mice, shrews, and similar little animals, on frogs, and occasionally on birds.



The Common Grass or Ring Snake grows rather larger than the Viper, and specimens are found up to four feet in length. It is the commonest of European snakes, but it does not live in Ireland. It is really a very beautiful and interesting creature and makes an excellent pet. It is fond of water, and on hot days loves to lie coiled up in a pond or to go swimming in the river. It lays its eggs in a manure heap and leaves them to be hatched out by the heat. In this it is different from the Adder, which produces its young alive from its body. The grass snake and adder cast off their skins from time to time, turning them inside out in doing so. The grass snake feeds on frogs, young birds, birds' eggs, and occasionally on mice. In colour it is brownish grey with a greenish tinge.

A BIRD THAT CAN KICK LIKE A HORSE

THE OSTRICH AND ITS WONDERFUL APPETITE

The old story that the ostrich is a very stupid bird and that when pursued it buries its head in the sand or in a bush, believing that because it cannot see it cannot be seen, is only a traveller's tale. Those who have studied the ostrich tell us that it is quite as intelligent as any other bird. If an enemy approaches its nest or pursues the mother bird and young, the cock will try to lead the foe off in a wrong direction by running in front of him or pretending to be wounded. Altogether, the ostrich is a very remarkable bird, as we read here.

The biggest bird in the world is the ostrich, and a very marvellous creature it is. A full-size male bird stands eight feet high, weighs three or four hundredweights, and can give a kick which will kill a man.

The ostrich has always been a very useful bird to mankind. In the southern part of Africa, which is its chief home, its huge eggs, weighing three or four pounds each, yield an excellent and nourishing food supply. Magnificent feathers from the wings and tail have provided not only decoration, but dress for the natives of Africa, and from time to time ostrich feathers have become fashionable in civilized countries. The cock has black plumage on the body and white wing and tail feathers. The hen's plumage is a dull, greyish-brown and is much less decorative.

There are several species of ostrich, one kind living in North Africa, Syria and Mesopotamia, and another kind in Somaliland, but the best known species is that found in South Africa, particularly in the Kalahari Desert, and in the country of the Matabele and Mashona peoples.

In desert country covered with patches of bush the ostrich can hide and yet watch for its enemies without being seen, for its long bare neck and small flat head rising above the bushes are difficult to discern at a distance.

A Runner Without Equal

The ostrich cannot fly, but as a runner it has no equal, and its outspread wings help its speed, acting in somewhat the same way as aeroplane wings. It can outstrip the fastest antelope or horse, and often reaches a speed of 26 miles an hour, but it has a foolish habit of running in a circle, so that it does not escape the hunter. It can live for long without water, but in the hot season if it is near a lake or the sea it will often bathe.

Perhaps the most extraordinary thing about the ostrich is its appetite. It is really omnivorous, and its food consists of small mammals, birds, snakes, lizards, insects, grass, leaves, fruits and seeds. But it does not stop at these things. It will swallow keys, nails, coins, buttons, and other metal objects, glass, stones, and in fact anything, but it is not always able to digest such strange fare, and there are several cases on record of ostriches dying after swallowing pieces of glass.

The Missing Snuff Box

One ostrich when dissected was found to have nearly a peck of stones inside its body, most of them being worn as smooth as if polished by a skilled lapidary. A consul at Tripoli missed a silver snuff box of considerable size and value, and many people were suspected of having stolen it. An ostrich which was kept in the grounds was, a little later, shipped to Europe, but died during the voyage. It was opened to ascertain the cause of death, and in the body were found nails, keys, pieces of iron and copper, part of a lantern, and the missing snuff box, the chasing and sharp edges of which had been worn completely smooth.

An ostrich resting on its powerful legs, one kick from which could kill a man

The male birds often make a noise like the roaring of a lion, and at other times, particularly in the morning, low like an ox. When they are feeding, however, they utter a kind of hissing chuckle, but the young birds are silent.

When the pairing season comes, the male bird will associate with several hens, all of which lay their eggs in a single nest, and then the cock does most of the incubating. He sits on the nest all night, so as to keep off jackals that would steal the eggs, and even in the daytime he covers the eggs for hours, though the female birds then take their turns. In the daytime the birds leave the nest altogether for considerable periods, covering the eggs with sand, and they are kept from getting addled by the Sun's heat.

In Somaliland the natives hunt the ostrich on camels, and at other times catch the huge birds by digging pitfalls. The bushmen of South Africa, on the other hand, dress up in ostrich skins and approach the birds so as to shoot poisoned arrows at them.

Plucking the Feathers

When ostrich feathers were very fashionable in Europe and America, a number of ostrich farms were started in South Africa, and some of the birds were taken to the United States in 1882, and ostrich farms started in California.

It is only the male bird that produces the beautiful feathers that are so much admired. When these are at their best the bird is placed in a wooden case with his neck projecting through a hole, and a hood like a stocking is put over his head. Then the feathers are clipped. The bird suffers no pain, as no blood is drawn and no nerve is touched.

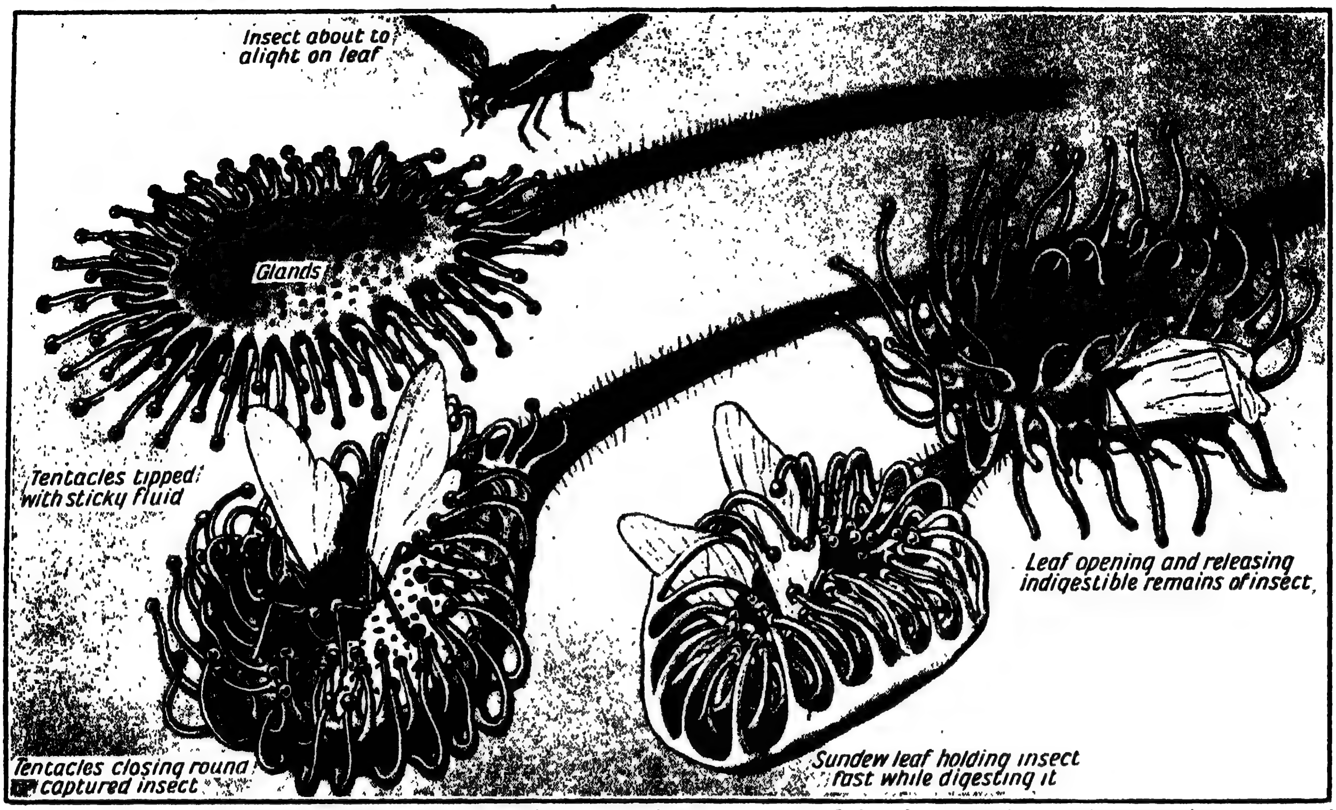
The ostrich's chief means of defence is its powerful legs, which can give a kick that will disable a fierce quadruped, but when fighting its own species it often uses its beak as well as its legs.

The Romans were very fond of ostrich flesh, and the Emperor Heliogabalus once had 600 cooked and served at a supper he gave. A notable Roman glutton named Firmius is said to have devoured an entire ostrich at one meal.

WHAT HAPPENS WHEN WE SMELL A ROSE

We all love to smell a rose or other sweet-scented flower, but not many people know exactly how it is we are able to smell. The thing we smell gives off tiny particles, generally in the solid state, but far too small to be seen or felt. These enter our nostrils and pass into the upper part of our noses, where alone the smelling is done. They have to be dissolved in a fluid before the olfactory, or smell, nerve can be excited and send a message to the smelling centre of the brain. That is why if the upper part of our nose becomes dry we cannot smell. When we have a cold, too, our noses become stopped, and we cannot smell because the particles are unable to reach the upper nose The nerves in the lower part of the nose, when stimulated as by pepper, make us sneeze, to expel the offending substance.

PLANTS THAT CATCH AND EAT INSECTS



There is a British plant, the sundew, shown here magnified, which feeds on insects. It has flat, round leaves whose margins are covered with short bristles, each ending in a knob that exudes a sticky liquid. When an insect touches one of these knobs it is held fast, and the hairs at once close over it. Then from a number of glands the plant pours out a juice by which parts of the insect are digested, the liquid containing the digested portions being absorbed and nourishing the plant. Afterwards the leaf opens and the remains drop out.

Another plant which catches and devours insects is the Venus Fly-trap, a native of North America. The leaves terminate in a hinged portion surrounded by a fringe of bristles. On the inside of each half of the trap grow three short sensitive hairs, and directly these are touched by an insect, the two hinged sections close up with a snap, like a rat-trap, and the imprisoned insect is then digested by juices.

WONDERS OF THE SKY

OUR NEAREST NEIGHBOUR IN SPACE

The Moon is the most familiar of all the heavenly bodies. We know it better than we do the Sun, although it is not so important to us. The Sun is too bright to be looked at very much with the naked eye, but we can study the Moon's face, and in the country on moonlight nights it is always pleasant to look at the Moon, which seems a real friend. It is nearer to the Earth than any other member of the Sun's family, and has indeed been called a suburb of our planet. Here we read many interesting particulars about the Moon

The vast space that surrounds us on all sides is filled with thousands of millions of moving spheres, most of them glowing balls of fire. The majority are so far away that it takes not only years, but in many cases thousands of years for their light to reach us across the intervening space, and yet light travels at the incredible speed of 186,000 miles per second.

There is, however, one heavenly body which is quite a near neighbour; in fact its distance is only ten times the circumference of the Earth. Or if we placed thirty earths side by side and touching we should bridge the distance between ourselves and this near neighbour. The heavenly body in question is the Moon, and it is the body of which we know most. By means of giant telescopes its surface can be brought so near to our eye that if there were on it a building the size of St. Paul's Cathedral we could detect it. We might even notice a regiment of soldiers, or a caravan on the march.

If the Sky were Full of Moons

But the first thing we notice about the Moon—and for that we need nothing but our naked eye—is that it is a bright body which gives us a great deal of welcome light by night. It is not, however, a ball of fire like the Sun, but a dead world or, as somebody has described it, a wandering corpse among the celestial bodies.

If the Moon is dead, why does it give us so much light? Well, this light is not made by the Moon; it is the sunlight shining upon it which is reflected out into space so that we see the Moon as a brilliantly lighted disc in the sky.

In contrast with the darkness of night the Moon is, of course, very bright indeed, but as a matter of fact it would take 600,000 full moons to give us as much light as we receive from the Sun. If the whole of the sky as we see it were packed with full moons we should still receive only about one-eighth of the light which comes from the Sun. Curiously enough the half moon does not give anything like half the light of the full moon, for there are many shadows on its surface and these reduce its light.

The Moon's surface reflects only about one-sixth of the sunlight that falls upon it. The total brightness of the full moon is reckoned as being equal to that of a hundred candle power lamp seen at a distance of 22 yards.

The Moon is often called a dead, cold world, and it is cold in the sense that it gives out no heat of its own, but as it receives sunlight it reflects not only light but a certain amount of heat. Its surface also absorbs some of the Sun's heat and then afterwards radiates or throws out this, just as a brick wall throws out some of the heat it receives from the Sun in the day.

It is only within the last century that men have been able to get any idea of the heat given out by the Moon.

The Moon being so small its gravitation or pull is much less than the Earth's, and in consequence a man on the Moon could do six times as much physical work as he can on our planet.

The most delicate thermometer is incapable of recording it even when the heat is concentrated by a powerful lens. A more sensitive instrument for measuring heat than the thermometer is the thermopile, and by means of this scientists tell us that the total amount of heat radiated by the full moon to the Earth is about one 185,000th of that which we receive from the Sun.

There are, however, on the Moon's surface amazing contrasts of heat and cold. When the Sun is shining upon its surface the temperature rises to over 100 degrees Centigrade. Sometimes indeed it may be as high as 120 degrees, which is 20 degrees above the boiling point of water. On the shady side, however, where the Sun is not shining, the temperature, Sir James Jeans tells us, is probably about −150 degrees Centigrade; that is, there are 150 degrees of frost. There is thus a range of about 270 degrees Centigrade in the course of a lunar day and night. But the drop in temperature is amazingly rapid.

Astronomers have found, by observing the Moon's surface during an eclipse, that when the Earth's shadow crossed the Moon's cutting off the Sun's heat, the temperature fell 175 degrees in a few minutes. It would certainly not be a pleasant world for us to live on.

Why is it that there are such extraordinary changes in the temperature of the Moon? Well, this is due to the fact that, so far as we can detect, our satellite has practically no atmosphere. We know this for several reasons. There is no distortion near the edge of the Moon's disc, as there would be if there were any appreciable atmosphere. Nor is there any haze such as would be caused by an atmosphere. The shadows of the Moon's peaks and craters are perfectly black and perfectly defined, unlike those of a world which has air.

No Atmosphere on the Moon

The Moon could not look so clear and sharp-cut had it an atmosphere of any kind, and another proof is that when the Moon passes between us and a star, the latter disappears immediately behind the Moon's edge. If there were an atmosphere on the Moon, the star would become obscured slowly, owing to the bending of the rays of light from the star by the Moon's atmosphere.

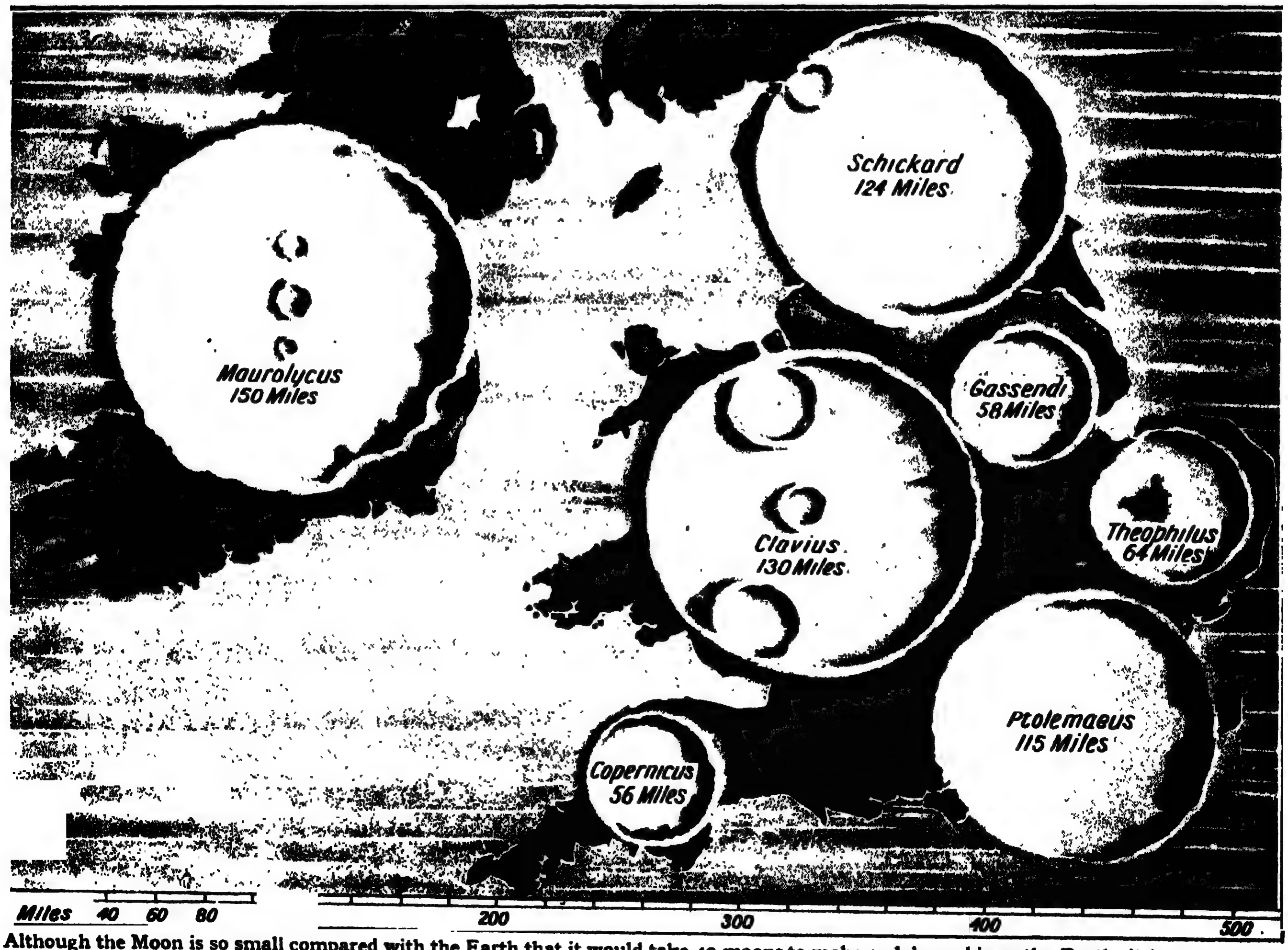
It is our atmosphere that helps the Earth's surface to retain the heat which is received from the Sun, and prevents its rapid radiation. In this way our climate is equalised so that we do not have those tremendous extremes of heat and cold which the Moon, being without an atmosphere, is compelled to suffer.

Another effect of the absence of atmosphere on the Moon is that our satellite is a silent world, for without air, or some other gas to carry the waves of sound, there can be no sound.

What is the size of this satellite that attends the Earth on its journey

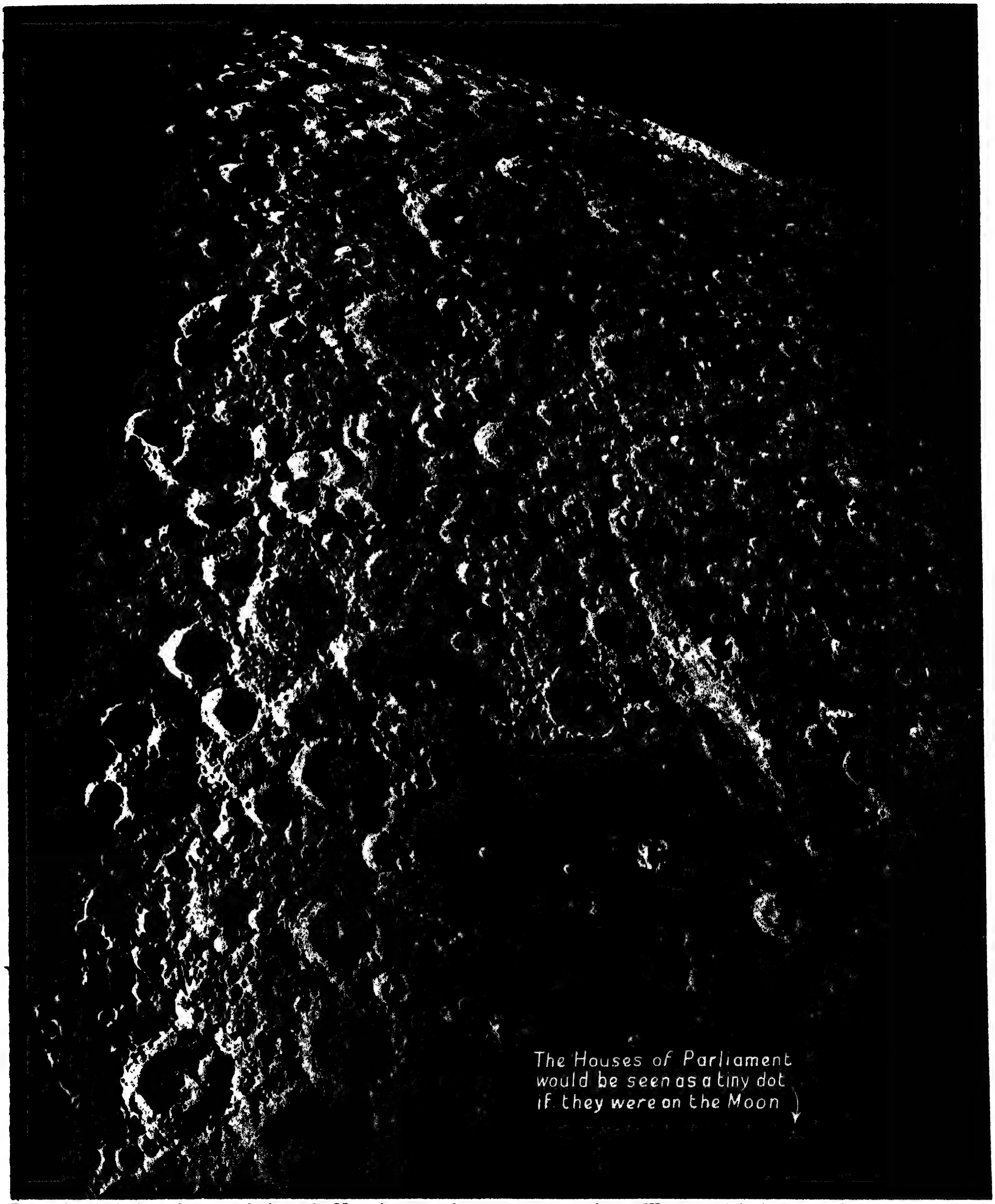
THE LITTLE MOON AND ITS BIG CRATERS

When we look at it in the sky the Moon seems as big as the Sun, but it only looks so because it is much nearer to us. Actually the Moon's diameter is only 2,160 miles, and this picture shows what the Moon would look like if it were placed in the Atlantic Ocean.



Although the Moon is so small compared with the Earth that it would take 49 moons to make a globe as big as the Earth, it has craters far bigger than any on our planet. We can judge their immense size by seeing what they would look like in the British Isles.

THE MOON BROUGHT WITHIN A FEW MILES



Even when looked at with the naked eye the Moon is seen to have an uneven surface. We can plainly distinguish its irregularities, and these are still more clearly seen through a good field-glass. But when viewed through a giant telescope such as the 100-inch reflector telescope at Mount Wilson, in America, the Moon indeed presents a marvellous sight. This wonderful telescope brings our satellite within a few miles of the eye, that is, we see its surface just as we should if looking down upon it from an aeroplane that was flying a few miles above its surface. Through this telescope a regiment of soldiers could be seen marching across the lunar deserts, and a building like the Houses of Parliament or St. Paul's Cathedral would appear as a small dot. The details of the many craters stand out with startling clearness. This splendid photograph, taken by means of the 100-inch telescope is published by courtesy of Mount Wilson Observatory.

round the Sun and through space? Well, it is very much smaller than the Earth both in size and weight. Of course, the Moon looks as big as the Sun in the sky, but this is only because it is so much nearer. While the Sun has a diameter of 864,000 miles, the Moon's diameter is only 2,160 miles, or a little more than a quarter of the Earth's diameter. The Moon could easily be put in the middle of the Atlantic without touching either Europe or America.

Many Moons to Make One Earth

It would take 49 Moons to make a globe the size of the Earth, and then this would weigh only about three-fifths of the Earth's weight, for the lunar rocks are not so dense as the Earth's. As a matter of fact, although the Earth is equal to 49 Moons in size, in weight or mass it is 81 times as great as the Moon. The area on the Moon is less than one-thirteenth that of the Earth, and North and South America together contain more square miles than the whole of the Moon's surface.

Of course, owing to the difference in size and density of the Moon, its pull on objects upon its surface is very different from that of the Earth's pull. An object weighing twelve pounds on the Earth would weigh only two pounds on the Moon.

For example, if a man in our world could carry one hundredweight, he could carry six hundredweights on the Moon. If he were able to jump four feet here he could, without any more exertion, jump twenty-four feet on the Moon. If he weighed twelve stone on the Earth, when he got to the Moon he would find that a weighing machine would indicate that he was only two stone. But, of course, without an atmosphere and without water, life would be impossible on the Moon. We could not, of course, light a fire, for there would be no air or oxygen to make it burn. If we could let off fireworks we should not hear a sound, as there would be no air to carry it.

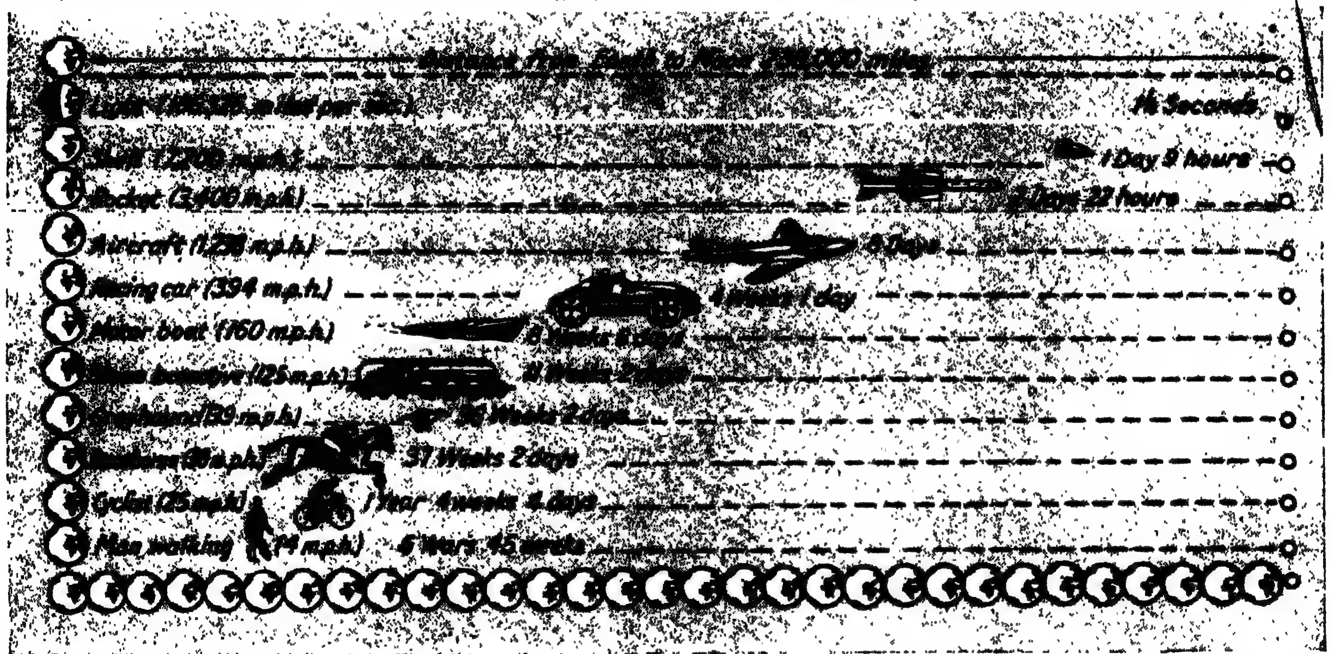
It is because of the weakness of the Moon's gravitation that its atmosphere and water have escaped; its pull was not strong enough to hold them.

Where did the Moon come from? Well, there are various theories. One is that it was once part of the Earth and flew off from the space which is now the Pacific Ocean when the Earth's matter was soft. Others think it is an independent planet which has been captured by the Earth's attraction. Another theory is that the Moon was an immense ring encircling the Earth as the rings of Saturn encircle that planet, and that later the ring became formed into a single globe.

It is nearest to the Earth our satellite is only 221,600 miles away. At its greatest distance, however, it is 252,970 miles. The mean distance is 238,000 miles. The Moon serves other useful purposes so far as man is concerned than those of giving light by night. It is the cause of our tides, as we find explained in another part of this book, and these are valuable not only for shipping purposes but for health purposes, too, as the coming and the going of the tides helps to keep our shores clean and sweet.

Value to Commerce

There is, in fact, a great deal of truth in what Professor Charles Young of Princeton University has said, that "If the stars and planets were all extinguished, our eyes would miss them and that is all; but if the Moon were annihilated the interests of commerce would be seriously affected by the practical cessation of the tides."



No heavenly body, except meteors, ever gets so near to the Earth as the Moon. Thirty Earths placed side by side would bridge the space between our world and the Moon. In this picture diagram we see how long a flash of light would take to reach the Moon from the Earth, and how long it would take everyday things on the Earth to reach the Moon travelling continuously.

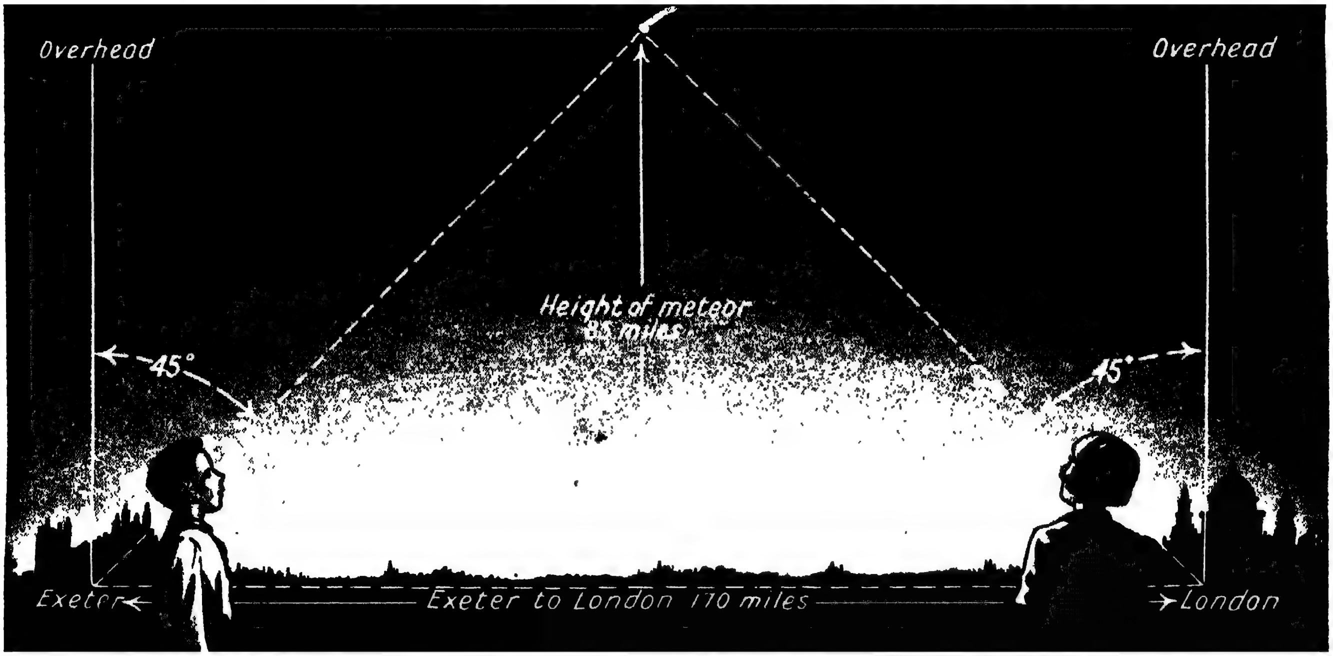
One very interesting thing about the Moon is that it always turns the same face to our Earth. This is because the period in which it rotates on its axis is the same as the period in which it makes one journey round the Earth. We, therefore, never see the other side of the Moon. What is this like? One authority—the Abbé Moreux, Director of the Bourges Observatory—thinks that the elevations on the visible disc which we see correspond to depressions on the opposite side which we do not see, just as the mountains of Europe and Asia are on one side of the Earth and the depression of the Pacific on the other.

The Moon's passage round the Earth is not a circle but an ellipse, and when

Shall we ever be able to reach the Moon? That is a question that has always fascinated mankind. When at the end of the eighteenth century man invented balloons, it was confidently asserted that sooner or later it would be possible to make a voyage to the Moon in a balloon. That, however, assumed that the space between the Earth and the Moon was filled with atmosphere in which the balloon could float.

We know better than that now, but in our our own time the possibility of a voyage to the Moon has been reasserted. This time, it is to be made not in a balloon but by rocket, and progress in rocket design and rocket fuels suggests that the sending of a rocket to the moon is not beyond possibility.

MEASURING THE HEIGHT OF A SHOOTING STAR



This picture explains how men measure the height of a shooting star or flashing meteor. Scientists are always on the look out, scanning the heavens. An observer in London sees a meteor flash across the sky, and another observer, say, at Exeter, also sees a meteor at the same moment. There is therefore little doubt that both saw the same meteor. The observer at Exeter records that he saw the shooting star to the east, halfway down from the point directly over his head, that is, a line from his eye to the meteor would form an angle of 45 degrees with the perpendicular. The London observer tells how he saw the meteor to the west, also halfway down towards the horizon from the point over his head. By reckoning a triangle, therefore, the base of which is the distance from Exeter to London, 170 miles, and the other sides of which are lines joining Exeter and London with the meteor, it is easy to work out by trigonometry the height of the meteor above the Earth. In this case, which is a very simple one, the height is 85 miles.

THE BLACK DROP OF VENUS

When the planet Venus in its journey passes between the Earth and the Sun we call this the Transit of Venus. Astronomers, from their observations of a transit from different points on the Earth's surface are able to measure the Sun's distance from our planet, but just at the moment when Venus enters or leaves the solar disc a curious appearance is seen.

The planet which, of course, looks black against the Sun's bright disc, appears to be attached to the Sun by a little black band, so that it seems like a black drop instead of a round disc. The cause of this strange illusion is not really known, although it is believed to be due to irradiation, that is, the apparent enlargement of an object that is strongly illuminated, owing to the vivid impression of light on the retina of the eye.

We can get somewhat the same appearance by placing the tips of two fingers lightly against each other, but not touching, and holding them up to the light.

The pear-like appearance of Venus at the Sun's edge

THE OLD MOON IN THE YOUNG MOON'S ARMS

When there is a crescent moon we often see the rest of the Moon very faintly as an ashy light. This is called "the old Moon in the young Moon's arms." What we see is reflected light from the

Why the crescent moon is sometimes seen on her back

Earth shining on the Moon. Sometimes the crescent is almost horizontal, and the Moon is said to be "lying on her back." The picture shows that this occurs when the Moon is vertically over the Sun, after the Sun has set or before it has risen on the Earth.

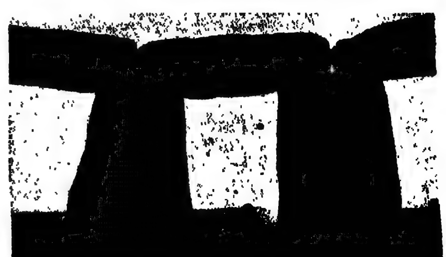
ENGLAND'S OLDEST TIMEPIECE

The primitive men who lived in Britain three or four thousand years ago built the great stone circles of Stonehenge, and used them partly as a temple of worship and partly as a calendar and timepiece.

On looking straight over the altar in the centre the eye sees a stone column in the distance that is known as the Hele or Sun Stone, and on June 21st the Sun can be seen to rise exactly over the top of this stone. It was in this way that the ancient Druids reckoned their summer season and the time of day

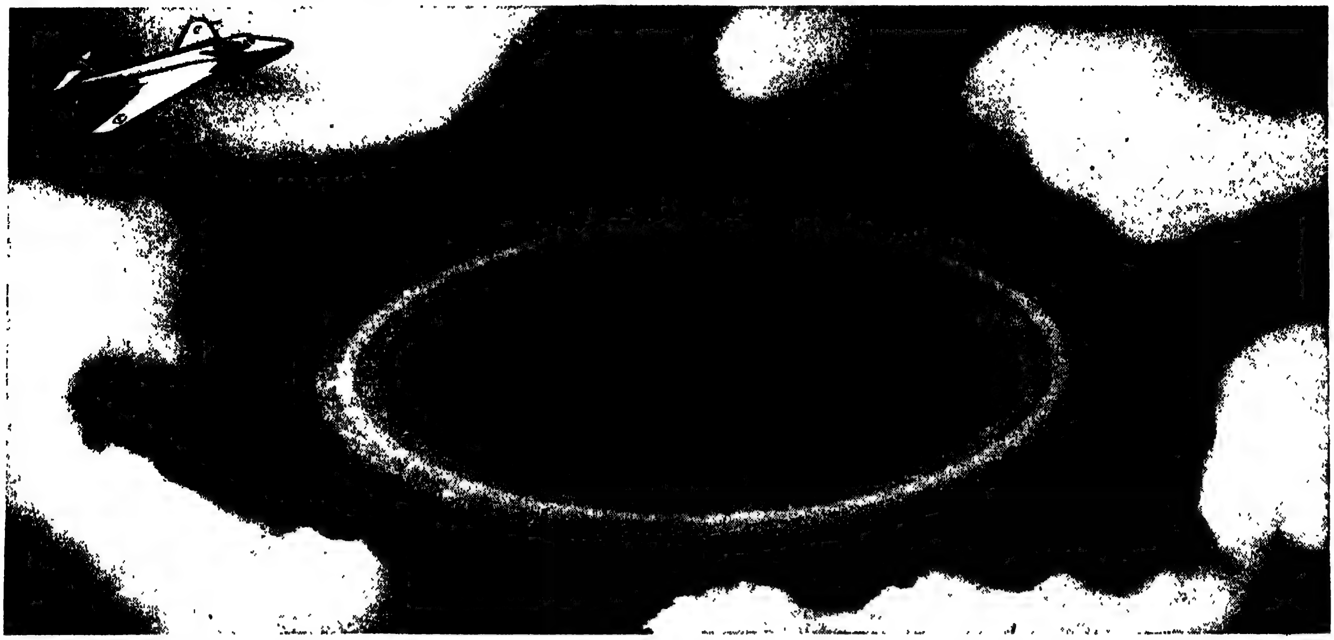
The men of old were great observers of the heavens, and long before clocks or other timepieces were invented they used to tell the times and seasons by the Sun. To-day, thousands of people go to Stonehenge on June 21st to see the Sun rise over the Hele Stone.

The remains of similar stone temples are found in other parts of England and also on the Continent of Europe and there too, no doubt, there were stones which were used as timepieces and calendars.

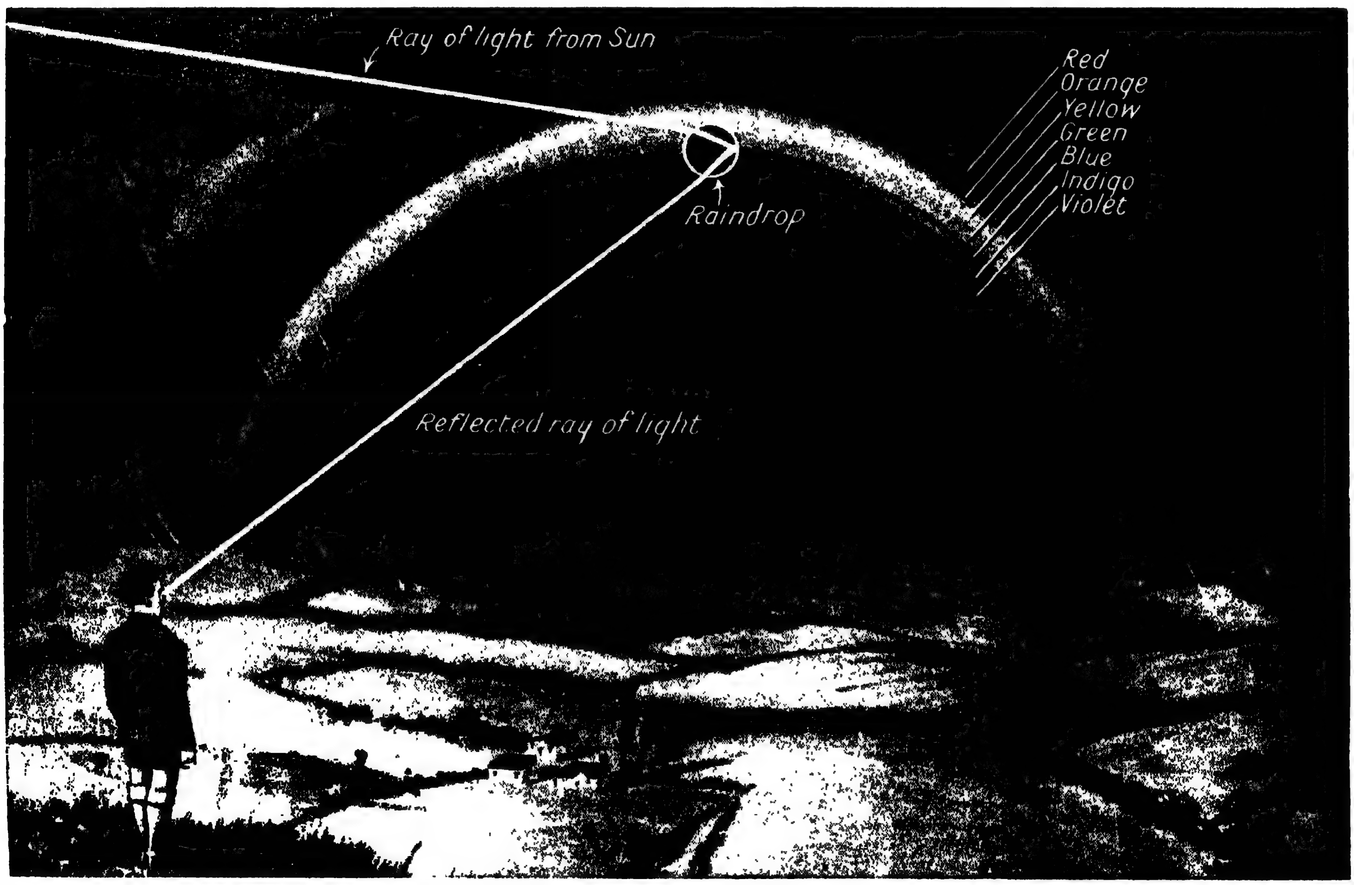


The Sun rising over the Hele Stone at Stonehenge on June 21st

THE MYSTERY OF THE RAINBOW IN THE SKY



When the horizon does not get in the way a rainbow is seen as a full circle of colour. Of course, when we are standing on the Earth we can never see a rainbow in this form, but the airman who goes high up above the clouds and looks down at the rainbow from above sees it in this circular form, and just as we often see from the Earth a second and fainter rainbow with the colours reversed so the airman sees a double circle of colour, as illustrated in this picture. In the centre of the rainbow he sees the shadow of his aircraft.



In this picture we see how a rainbow is caused. A ray of light from the Sun strikes a raindrop, is bent as it passes through it, and is then reflected back again from the inside of the drop and being bent once more reaches our eye. But the ray of light from the Sun is not only bent and reflected ; it is broken up, or refracted, as men of science say. This divides it up into the seven colours, violet, indigo, blue, green, yellow, orange, red, and it is these colours which we see. Of course, it is not only the light reflected from one raindrop which reaches our eye, but from many. We do not see all the colours from the one raindrop. The particular colour we see from each drop depends upon the angle at which the light from it is reflected to our eye. From this explanation of how the rainbow is formed it will be clear that no two people can possibly see the same rainbow, for we all have the colours reflected to our eye from different drops of rain.

HOW WE USE THE FORCES OF NATURE

If the men of the Stone Age could return to the Earth today, they would be amazed at the achievements of their descendants. Giant buildings rise into the clouds, powerful machines turn out goods at an astonishing rate, and trains, motor cars, aeroplanes and boats travel at scores of miles an hour. How has this all been accomplished? It has been done by using materials and harnessing powers which already existed on the Earth. Here we read something about man's ingenuity in using the forces of Nature

Man can create neither power nor matter. This may seem a strange thing to say in view of the fact that with iron and coal taken from the earth he can produce a marvellously powerful engine or machine which will yield many thousands of horse-power and do work which man himself, unaided, could never perform. It certainly looks as though he had really created something from the materials he has used.

Nevertheless it is quite true that the man who made the machine and produced the vast power created nothing. All he did was to transform and use something already existing and so harness the forces of nature for his own purposes.

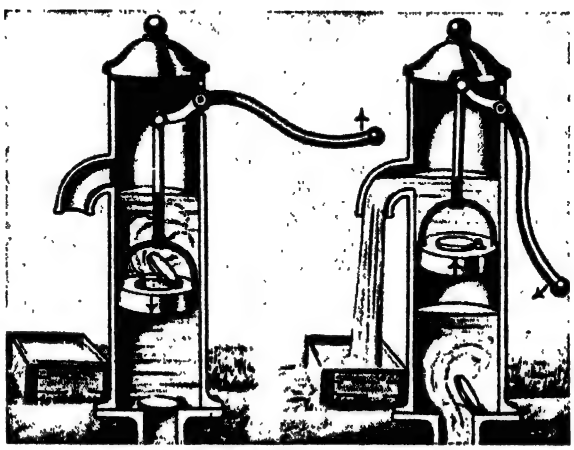
Everywhere in nature we find mighty forces and, in his struggle for a richer and fuller life, man is now able to use and control many of these. Niagara, rushing over a precipice and crashing into the channel below, is harnessed and lights cities for hundreds of miles round, driving also trains and tramcars and machinery for the production of goods of all kinds. A power-station is built and equipped in London and supplies electricity over an area of many square miles, and from the electricity produced by the generators we are able to light and heat our houses, to cook our food, and to travel to and from our work

Harnessing Niagara

But nothing has been created. In the case of Niagara a mighty natural force running to waste has been harnessed for man's use, and at the power station in London natural forces already existing have simply been transformed and directed into certain channels.

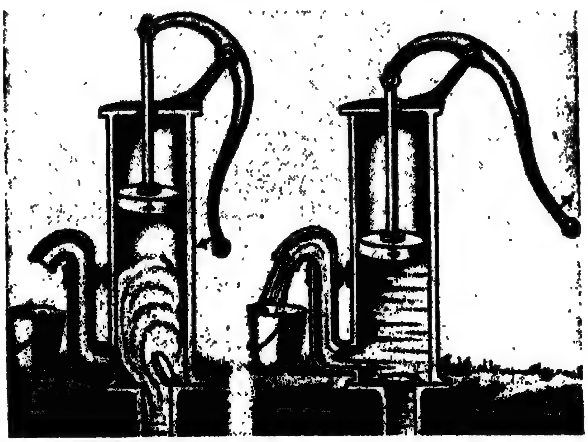
Electricity cannot be produced from nothing. If it is generated by a dynamo going round and round something has to make the dynamo rotate. Either we use the descending water of a waterfall, or we burn coal in which for millions of years the sun's energy has been stored up. Then, we transform the heat into another form of energy called electricity. And so it goes on. In everything we do we merely transform or harness some matter or power already existing in the universe.

Even if we use our own arms to turn a windlass and draw up water from a well we are creating nothing, although perhaps at first thought it looks as though we were; we are merely using power which our bodies have obtained from food and sunshine, just as the steam engine gets its power from the coal put into the furnace.



THE SUCTION OR LIFT PUMP

The handle being raised (left) lowers the piston, and its valve being opened by the pressure of water from below allows the water to flow through. The pressure of the piston closes the valve of the pipe leading down to the water supply. The handle is now lowered (right), raising the piston and lifting the water above it so that it can flow out of the nozzle. The pressure of the water above closes the piston valve, and the raising of the piston produces a vacuum underneath, when, at once, the lower valve opens and water rushes up to fill the vacant space.



HOW A FORCE PUMP WORKS

Here (left) the handle is pushed down, raising the piston, which has no valve. A vacuum being caused underneath, water is forced up from below to fill the space, and when the handle is raised (right) the piston goes down, forcing the water out of the nozzle. The valve of the pipe leading to the water supply is then closed by the pressure of the water above till this has been forced through the nozzle.

The crashing of a waterfall, the flash of lightning, the power of the incoming tide, the explosion of gunpowder or dynamite, and the release of nuclear energy, are all forces obvious to the eye, but there are also unseen forces, silent and often unnoticed in their workings, and these, too, we are able to use.

Take, for instance, the atmosphere, that unseen ocean that covers the Earth everywhere and at the bottom of which we live. We only realize its full force when a hurricane is blowing, and then it may be so powerful as to blow our houses down. We read more about the wonders of the atmosphere in another part of this book, but let us look at one familiar example of the way in which the atmosphere works for us.

The Secret of the Pump

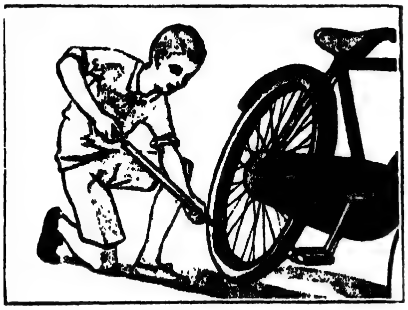
The air presses in all directions with a weight equal to just over fifteen pounds on every square inch of surface.

In pumping water up from a depth, whether we use the common lift pump or the force pump, we are making use of this pressure of the air to bring the water to us from a depth. The pictures on this page show exactly how these pumps work, and why the water comes out.

We are harnessing the power of the air to do work for us that we could not perform so easily in any other way. It is interesting to remember this whenever we perform any task at all. Even if we compose a letter or a poem we are not really creating anything; we are transforming energy which already exists. In some subtle way the mind depends upon the brain, for if the brain is injured or starved the mind does not work, and the brain is maintained by means of food and sunshine supplied to it from outside

EXPERIMENTS THAT SHOW THE AIR IS MATTER

As we cannot see the air we breathe, we might almost be inclined to think that it does not exist Being invisible it scarcely seems a substance in the same way as earth, water or the black smoke that comes from the chimney We can feel the earth and the water, and if we put some into a tin or tumbler we know it is



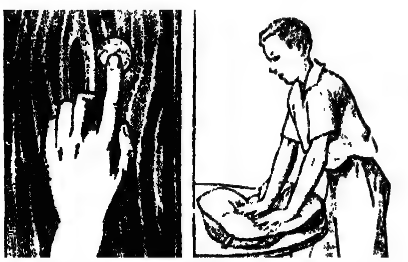
When a bicycle tyre is full of air it is difficult to pump more in

there because we not only feel its weight but see it too

But although we cannot see the air we must remember that it is just as much a substance as iron, or lead, or wood It is easy to prove this by a number of very simple experiments that we can carry out in our homes.

If we fill a tumbler with water to the brim we cannot get any more in If we fill a box with sand to the top we can sometimes get a little more into the box by shaking the sand down and packing it closer, but when the box is really full and packed tightly we cannot put more sand into it.

It is just the same with air. Let us pump up our slack bicycle tyre and at first it is quite easy, but when the tyre is right up there comes a time



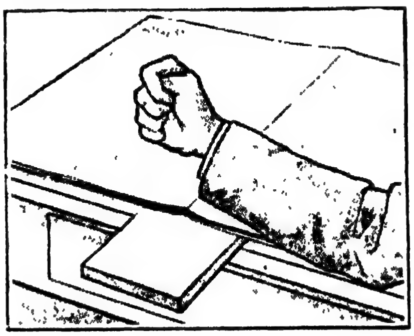
An experiment to show how air pressure will support a coin, and (right) a rubber cushion full of air

when we cannot push in the pump; the tyre is full of air and will take no more In the same way if we press down on an air cushion that has been blown up we cannot squeeze it flat As we press down in one part, the cushion gets bigger in another because we press the air from the one part into the other

If we move our open hand about in water we find the quicker we try to move our hand the more difficult it is. The water is in the way and impedes the motion of the hand In the same way if we try fanning ourselves quickly with a fan the fan is either impeded or bent by the pressure that the air exerts

Everywhere the air is pressing upon us and upon everything in all directions with a pressure that is equal to fifteen pounds on every square inch It presses up as well as down, and if we doubt it we can prove the matter Let us fill a tumbler to the very brim with water and on top place a sheet of thin card, having first wet the edge of the tumbler. Now, holding the card in position we invert the tumbler and if we have placed the card on tightly so that no air can get between it and the water, the water will remain in the tumbler with the card over the mouth It is kept there by the pressure of the air underneath.

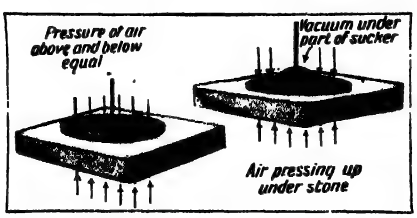
Similarly, when a boy uses a sucker, that is, a disc of leather with a string through the middle, he can prove the great pressure which the air exerts He wets the sucker, puts it on the pave



The pressure of the air prevents the board being knocked on the floor

ment and then presses upon it with his foot That drives out all the air between the sucker and the paving stone Now when he pulls he cannot, without the greatest exertion, draw the disc of leather from the stone, for the air is pressing upon it with a weight of fifteen pounds on every square inch

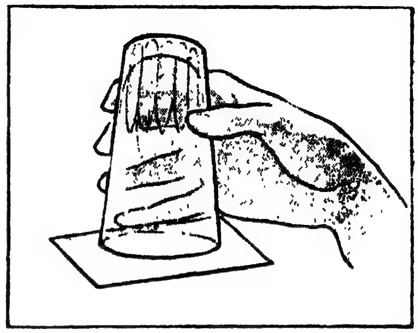
If the sucker is placed upon a small, flat stone and pulled up hard the middle of the disc will be raised a little but there will be a vacuum between that part and the stone. The result is that more air will be pressing under the



Why a sucker lifts a stone. Air pressure underneath is greater than above

stone than on top, and so if we lift the string with the sucker we bring up the stone with it. The stone is held to the sucker by the pressure of the air underneath.

Another experiment that shows the air presses in all directions may be performed with a smooth penny Place it against some woodwork, press on it with the finger, and then give it a sharp push up or down. In doing so we press out the air between the penny and the woodwork, and when we remove our finger the penny will remain as

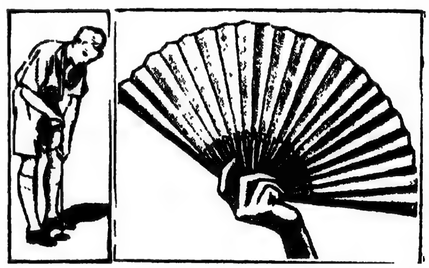


The air supporting the water in an inverted tumbler

though stuck to the wall It is the pressure of the air upon the outer surface of it that holds it there

Another interesting experiment to show the pressure of the atmosphere may be carried out with a board about two feet long and five or six inches wide Place the board on a table, the kitchen table for preference, with about six inches projecting. Open out a newspaper and lay this upon the board smoothing it down

Now clench the fist and give a sharp downward blow upon the projecting end of the board We naturally expect the board to tip up and fall on the floor, but it does not move The end of the board will even break off before the board will tip up

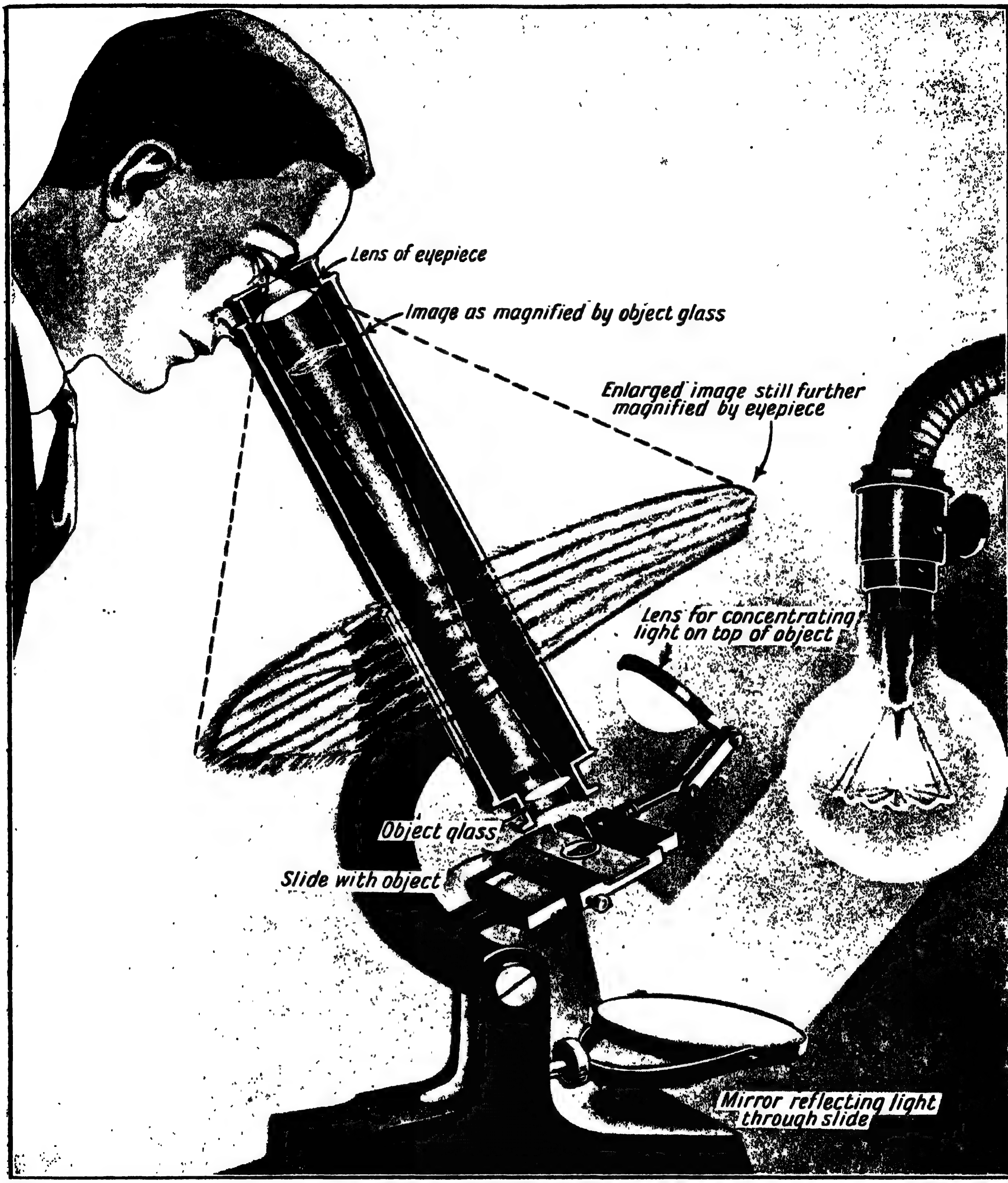


A boy trying to pull up a sucker, and (right) a fan extended to catch the air

The explanation is that the air is pressing upon every square inch of the newspaper with the weight of fifteen pounds, and when we give the sharp blow to the plank the air does not have time to rush in between the table and the newspaper The result is that when the other end of the plank tries to rise it has the very heavy weight of the atmosphere pressing on the newspaper to hold it down.

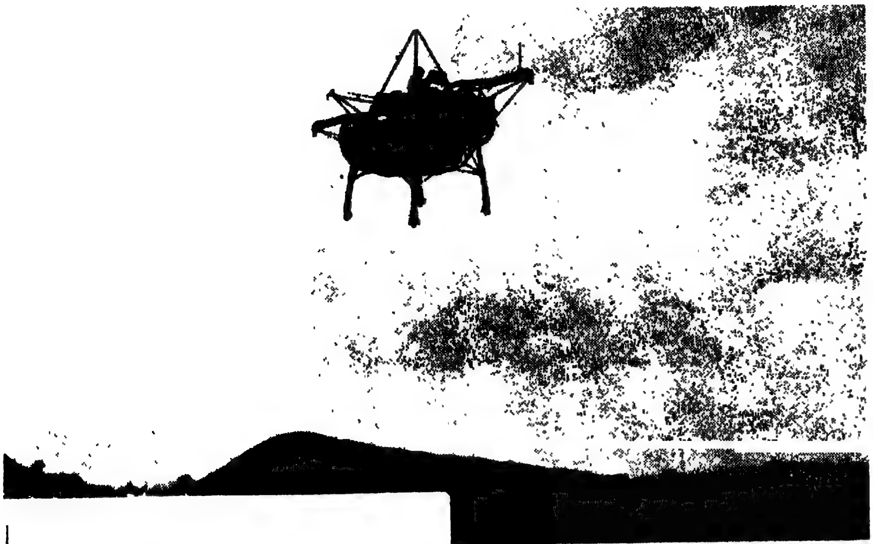
Of course, the blow must be short and sharp or the experiment does not succeed If we give a prolonged blow and press on the end of the board we give the air time to get in under the newspaper, and then, of course, the air above and below the paper is equalised and the board will tip up.

HOW A MICROSCOPE MAKES THINGS BIG

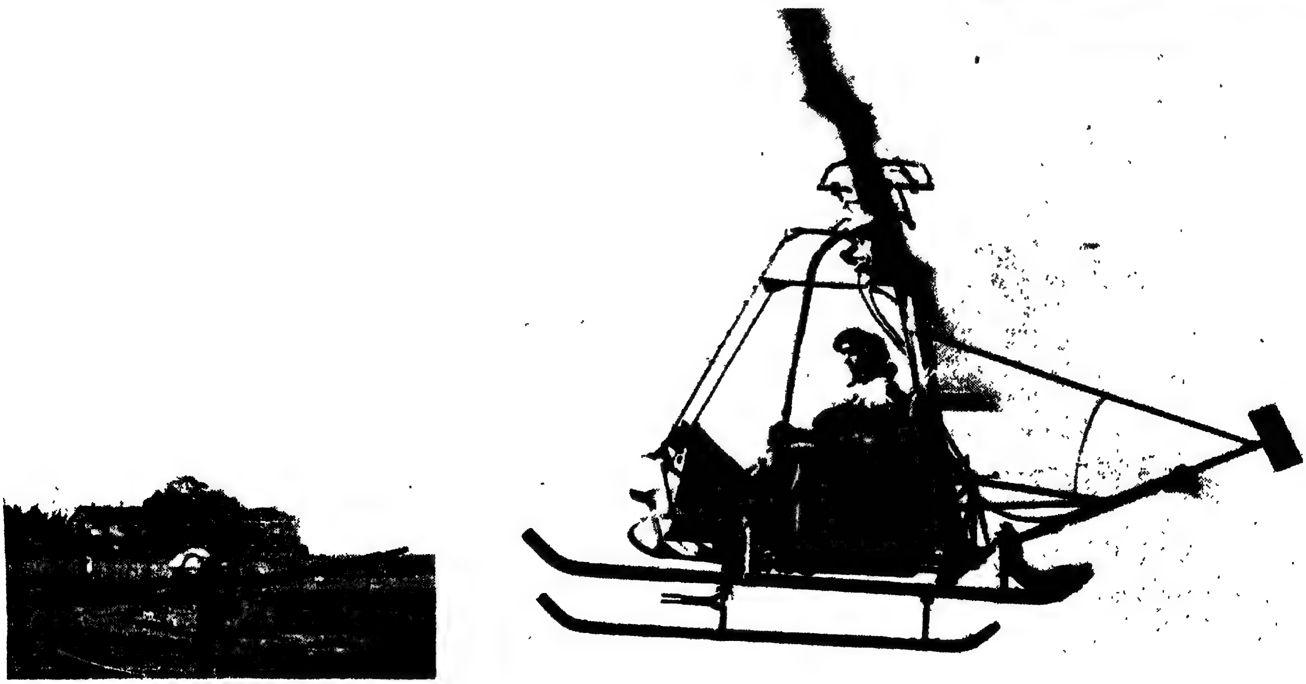


This picture shows how a microscope makes small objects appear very large. The object to be magnified is in a glass slide, and this is placed on a stage and illuminated from above or below, according to whether it is opaque or transparent. In this case the object is a tiny insect's wing, and being transparent is illuminated from below. Rays of light pass from it to a magnifying lens known as the object glass. The curved lens causes the rays to be bent at an angle and to cross one another, so that at a certain point in the microscope tube a magnified but inverted image of the object appears. This object is still further magnified by another lens in the eye-piece. When the rays of light reach the eye, the eye imagines that they have come in straight lines instead of being bent, and so the object appears much enlarged, as though it were near the object glass. In this picture the microscope is greatly simplified so that its principle may be easily understood In modern instruments both the object glass and the glass of the eye-piece consist of several lenses, so arranged that they will rectify the distortion that is caused by the curvature of the glass.

AIRCRAFT THAT FLY WITHOUT WINGS



A disadvantage of the aeroplane with fixed wings is that it must travel along the ground before take-off and after landing. Helicopters of the type illustrated in pages 1368-69 can take off from and land on areas not much bigger than the circumference of their rotors. Other contributions to the solution of vertical flight are illustrated in these photographs. Above : the Rolls-Royce Flying Bedstead which has neither rotor nor wings but derives its ability to ascend, fly, and descend by altering the direction of the jet streams from two turbo-jet engines. Left, the U.S. Army's flying platform, which ascends and descends by altering the air flow from a ducted-fan engine ; horizontal movement is by the pilot changing the position of his body. Right : the Altar Volant, a French version of the Flying Bedstead. Below : the Dutch Kolibric, a light-weight helicopter with a rotor driven by a ram-jet engine mounted on each blade tip : this type of machine has been of great assistance to engineers watching progress on dykes and other land reclamation schemes



THE FIGHT THAT CHANGED THE FACE OF ENGLAND

There has been one battle on the soil of England the result of which changed the whole face of the country. That battle was the battle of Hastings. As most people know, it led to a complete change in the system of government, but it did more than that. William the Conqueror, having made himself master, destroyed many villages, houses and churches in the South to plant a great forest—the New Forest—in which he could hunt for sport; while in the North, after a revolt, he devastated a wide territory and left no house standing between York and Durham. Finally the whole country was dotted everywhere with Norman castles to keep the people in order. The face of England had been changed by a single battle

When news was carried to Duke William in Normandy that Edward the Confessor was dead and that Harold, the son of Earl Godwin, had been crowned King of England in Westminster Abbey, Duke William was very angry. He at once sent a messenger from Normandy, who addressed Harold in these words:

"William, Duke of the Normans, sends to remind thee of an oath which thou hast sworn to him with thy mouth, and with thy hands upon good and holy relics."

"It is true," replied the Saxon king, "that I took an oath to William, but I took it under a constraint. I promised what did not belong to me, a promise which I could not in any way perform."

Some years before Harold had visited Normandy, where Duke William made a great fuss of him. Then he made the Saxon earl swear on two little caskets of holy relics that he would assist him in obtaining the kingdom of England after the death of Edward the Confessor. Harold was in the duke's power, and, thinking that it would not be safe to refuse, he swore the oath, the whole assembly crying out "May God be thy help!"

A Broken Promise

But Harold had no intention of keeping his promise, and after Edward's death he at once allowed himself to be made King of England.

As he would not give up the crown to William, the Norman duke decided to come and take it. He gave orders for a large number of ships to be built to carry an army across the English Channel. Men began to cut down trees and saw and plane them into planks. Many ships were built, and then when they were ready weapons of all sorts were placed in them, with food and wine, and by the end of August in the year 1066 the ships were ready to sail with a large army that had been gathered on the shores.

This army included stout and brave warriors from many parts of France and Flanders. William made them all sorts of promises, and as he declared that the war he was going to wage was to punish a man who broke a solemn promise, he asked the Pope at Rome to bless his expedition. The Pope sent him a banner and a ring containing what was said to be one of St. Peter's hairs.

This gave the expedition a sacred character, and when one of William's leading men declared: "Yours is the good right, and you have valiant knights; undertake, then, boldly, for that which is boldly undertaken is half accomplished," it seemed that all was ready for a successful expedition.

But Harold was not idle. He gathered ships and men, and caused them to sail up and down the Channel between England and France, watching for the invaders.

Harold swears that he will help William gain the English throne

If Duke William could have sailed when he wanted to do so—that is, in August, as soon as his armament was completed—he would probably have been badly beaten, for the English had a powerful array of ships on the sea and a big army waiting on the land. But the winds were contrary, and so William was detained for a month, and in this time many things happened which were bad for the English.

The Normans also had had a bad time. The fleet made a start, but a violent hurricane came on and some vessels were dismasted, while others foundered with their crews. The troops began to murmur.

William himself seems to have become anxious. He often repaired to church and remained long in prayer, and then on quitting the church looked up at the weathercock on the steeple to see if the wind had changed.

And what had happened to the English meanwhile? Well, Harold's brother Tostig, who had been Earl of the Northumbrians but had been banished, obtained the help of another Harold, known as Hardrada, or the Stern in Counsel. This man was King of Norway, and he came with a fleet and army and landed on the coast of Yorkshire.

News was carried to King Harold of England in the South, and he at once marched northwards with his army and fought a great battle at Stamford Bridge, utterly destroying the Viking host. But it was a hardly won battle, for many of Harold's best men were killed in it.

William Sets Sail

Meanwhile, Duke William had set sail from Normandy. His fleet was said to have consisted of 400 ships with large masts and sails and more than 1,000 transport boats. William's vessel led the van, and at his masthead flew the banner blessed by the Pope. At the prow was carved the figure of a boy with his bow bent and an arrow ready to speed its way. Lanterns were fixed to the masts to serve as beacons and a rallying point for the fleet at night.

At last the Channel was crossed, and William and his men landed safely and without opposition at Pevensey.

There were two reasons for this. In the first place, Harold's fleet, which had been waiting for weeks to catch William and his army on the sea, had had to return to port for lack of food, owing to the long delay. That gave William's ships a free passage. Then, as Harold and his army were away in the North, William and his men could land without opposition. It was very unfortunate, indeed, for the English, but lucky for the Normans.

Messengers rushed off at once to Harold and told him the news, and he

marched southward; but his army had been weakened, and when it arrived to face William and his Normans the English soldiers were tired.

It was on September 28th, 1066, that William landed on the English coast. The archers went ashore first, and as they wore short cloaks and had their hair shaven off, word was soon carried to Harold that there were more priests than soldiers with the Norman army. Harold smiled at this news.

"Those whom you have seen in such numbers," he said, "are not priests, but good soldiers who will make us feel what they are."

After the archers, the horsemen landed, clad in coats of mail and wearing helmets of polished iron of a conical shape. They were armed with long and heavy lances, and straight two-edged swords. After them came the workmen of the army---smiths, carpenters, and so on—who took ashore with them the material for three wooden castles which had been framed and prepared beforehand.

William by a clever idea turns his fall into an omen of victory

The Normans Tremble

Last of all, Duke William landed, and as he put his foot upon the sands he slipped and fell. It was a superstitious age, and at once his followers cried out:

"God preserve us! This is a bad sign!"

But William was equal to the occasion.

"What are you crying out for" he said "Don't you see I have seized on this land with both my hands?"

And, holding up his arms, he showed that he was grasping the soil with both hands.

This clever reply set the fears of the Normans at rest, and what might have been regarded as an ill omen became a good sign.

The Norman army marched to the town of Hastings and there formed a camp, setting up two of the wooden castles and furnishing them with provisions. Then bodies of soldiers over-ran the neighbouring country, seizing the cattle and burning the houses of the people. The English fled from their homes and flocked to the churches, thinking that the religious Normans would regard the sanctity of these places. But they did nothing of the kind.

Harold's army, weakened by the battle of Stamford Bridge, was much less numerous than that of the Normans, and he hoped to surprise William's camp. But William was too clever a general for that to happen. His horsemen gave notice of the approach of the English king, who, they said, appeared to be marching on like a madman.

Seven miles from the Norman camp, Harold halted, and, changing his plans, he now entrenched himself behind a ditch surmounted by palisades. Some of the English captains wanted Harold to retreat towards London, ravaging the country as he went, so that the Normans, if they followed, would find no food. But this Harold would not do.

Duke William seems to have been rather anxious to settle matters without a battle, if it were possible, and he sent a monk to the English king making three propositions. He suggested that Harold should resign his crown to the duke or refer the dispute to the arbitration of the Pope, who was to decide which of the two ought to be king; or, suggested William, the matter should be settled by single combat between the English king and the Norman duke.

Harold abruptly refused all three suggestions. He was not prepared to give up his crown; he knew that the Pope was on the side of William, and with a stout warrior like William single combat was too uncertain a chance.

On hearing of Harold's refusal, William sent the monk back again.

"Go and tell Harold," he said, "that if he will keep his former pact with me, I will leave all the country beyond the Humber, and will give to his brother Gurth all the land which Godwin held."

Victory or Death

Harold, however, would have none of this, and the English promised him by their unanimous oath to make neither peace nor truce nor treaty with the invader. They would, they said, either die or expel the Normans.

Thus a day went by, and at night the scene in the two camps was very different. In the Saxon camp there was singing and merry-making, while in the Norman camp, which had many priests and monks, there was prayer and other religious exercises.

In the morning the Normans proceeded to the attack. Duke William rode on a Spanish charger, and round his neck were suspended some of the relics on which Harold was said to have sworn. The standard blessed by the Pope was carried at the duke's side, and as the troops were about to start forward, William cried out:

"Remember to fight well and put all to death, for if we conquer we shall all be rich. What I gain you will gain If I conquer you will conquer. If I take this land you shall have it. Come on, and let us, with God's help, chastise these English for their misdeeds."

The Norman minstrel goes into battle singing the Song of Roland

It was a queer speech, which shows the spirit of the times. In those days, perhaps more than in these, men were able to deceive themselves that when they were out for their own advantage they were doing God service.

While the soldiers went forward to fight the Saxons, their priests and monks went up a neighbouring hill to pray for victory.

A Norman minstrel named Taillefer, or Cleaver of Iron, spurred his horse forward, singing the famous song which tells of the exploits of Charlemagne and Roland. As he sang he played with his sword, hurling it in the air and catching it again in his right hand as it came down. All the Normans joined in the chorus and cried, "God be our help!" Then the minstrel rushed forward, cut down two Englishmen, and was soon cut down himself.

The English behind their redoubt held a strong position. As soon as they were within bow-shot, the Norman archers let fly their arrows and the crossbowmen their bolts. But the high parapet of the English redoubt deadened their effect. Then the infantry and the cavalry with their spears and swords advanced, but when they came within reach the English struck heavy blows with their battleaxes and broke the spears or clove the coats of mail. In no way could the Normans break up the English defence, and tired after their unsuccessful attack, they fell back.

William rallies his fleeing warriors when they think he is dead

The sun was setting in the west and the victory was still undecided. A great idea now came to William. He told his archers to shoot not point-blank, but upwards, so that the arrows might fall beyond the rampart. As a result many of the English were wounded in the face and head, and poor Harold himself was struck in the eye by an arrow.

But again when the Normans came forward they were repulsed, and as their horses stumbled they fell pell-mell into a ravine, where numbers perished. A rumour spread that Duke William was killed, and at this the Normans began to flee in real earnest.

But the story was not true, and William, throwing himself before the fugitives and threatening them with a lance, cried out: "I am here. Look at me. I am alive, and with God's help will conquer."

Harold falls dead at the foot of his standard

The Normans rallied, and again attacked the English redoubt, but nowhere could they make a breach.

Things were looking serious for the Normans, when the Duke had another bright idea. It was clear that the English could not be defeated unless they could be drawn from their position of strength, so William ordered a thousand of his horsemen to advance and then immediately to take flight. The ruse was successful. Directly the English saw the Normans fleeing they set off in pursuit, and then when they had broken their own ranks bodies of Norman horsemen and footmen rushed in.

The fighting now became hand to hand, and William had his horse killed under him. Harold and two of his brothers who were fighting with him fell dead at the foot of their standard, and a Norman, plucking the English flag from its place, set up the Pope's banner in its stead.

The English King and his lieutenants were dead, large numbers of his men were wounded, and now as there was no rallying-point, hope was lost. The English fled and the Norman horsemen pursuing gave quarter to none.

On the next morning, which was Sunday, Duke William rode over the battlefield and saw that his fallen warriors were decently buried.

Many English women came to beg the bodies of their fallen kinsfolk, and William allowed these to be taken to the neighbouring churches for burial, but he declared that if the body of Harold should be found it was not to have Christian burial, for the dead King was a perjured man excommunicated by the Pope.

Harold's mother, Gytha, offered the weight of the body in gold to be allowed to bury her son at Waltham, but William refused, and a body said to be Harold's was buried in a cairn on the rocks at Hastings.

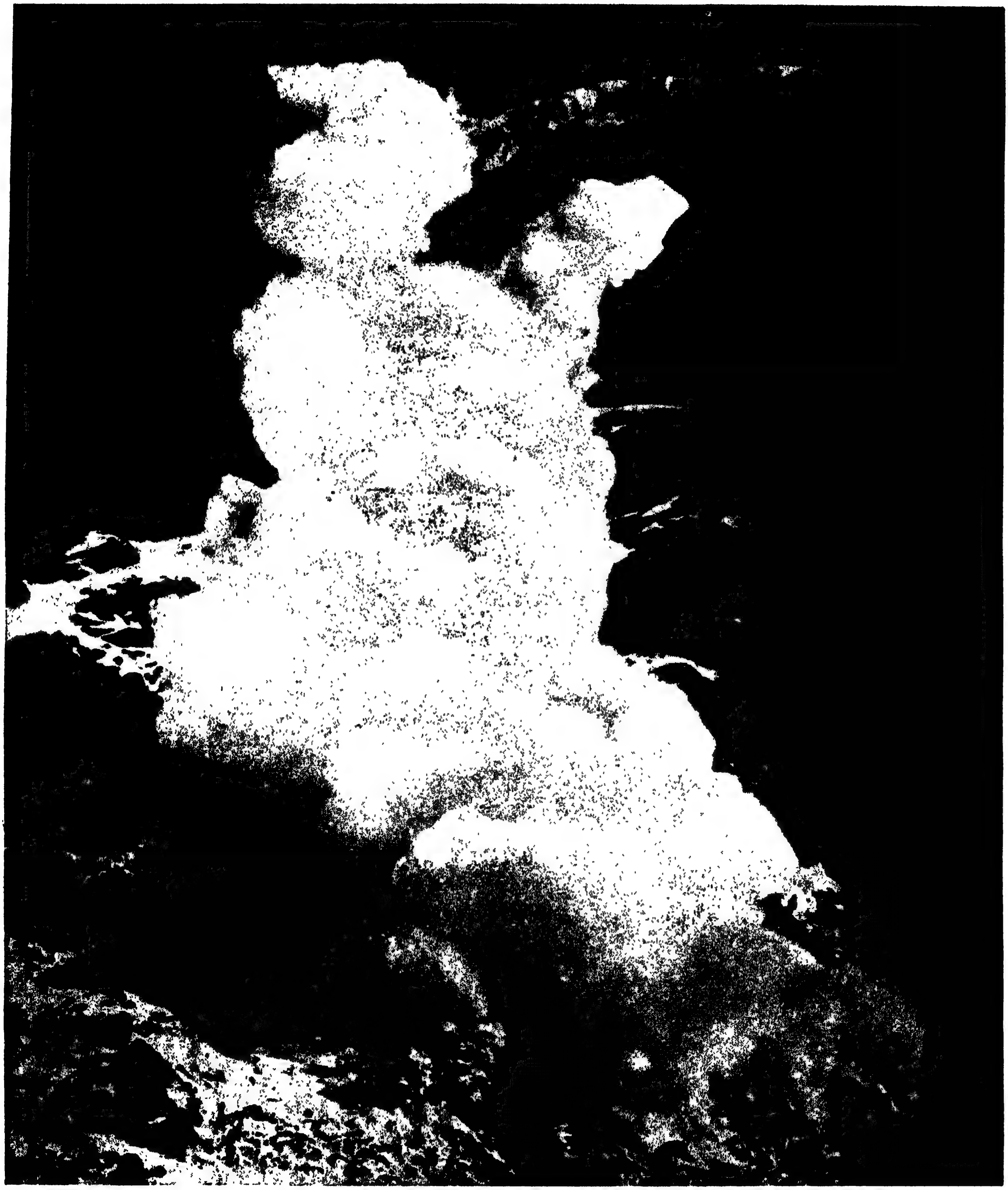
Later, however, it was said that a woman called Edith, who had loved the English King before he mounted the throne, discovered his body although it was much mutilated by wounds, and that eventually William allowed it to be buried at Waltham. Probably what happened was that the body was first buried among the rocks at Hastings, and afterwards removed and taken to Waltham.

There grew up a tale in after days that the English King had not really been killed at all, but though seriously wounded was found by some women and was secretly removed to Winchester, where he was nursed for two years in a cellar by a Saracen woman.

Gradually he recovered his health, but he found that everywhere England had submitted to William, who was now strongly seated on the throne, and that without foreign help it would be impossible to remove him. Harold sought such help, but failing to secure it, he gave up all such ambitious ideas, took the pilgrim's staff and wallet, and journeyed to Palestine. Then in old age he returned to England, and after living many years as a hermit, died at Chester.

The Battle of Hastings had been lost and won, and as a result the whole face of England was changed.

10,000 TONS OF SNOW CRASH DOWN THE MOUNTAIN



When the snow has accumulated on the mountain top very often a touch or a sound will set it hurtling down until finally it crashes into the valley beneath. Woe betide any living creatures that happen to be in the way, for not only the snow itself, but the compressed air it drives in front and to the sides will uproot trees and carry houses away. The best protection against an avalanche is a forest of trees, which break the fall, but about 100 lives are lost every year in the Alps alone through the fall of avalanches. In this wonderful photograph we see more than ten thousand tons of snow falling down the Wetterhorn in the Swiss Alps. It is the most remarkable photograph of an avalanche actually falling that has ever been taken, and shows the strange cloud-like effect of the descending snow. Scientists are now able to study the action of avalanches by means of slow-motion moving pictures taken from vantage points in the mountains.

THE REGIONS OF EVERLASTING SNOW

The world's lofty mountain peaks are covered with perpetual snow, but of course all the snow that falls upon them cannot remain in position. Sometimes it melts, and sometimes great masses of it fall down the mountain side in an avalanche. Here we read something about the everlasting snows and the terrible avalanches

In all parts of the world there are regions of everlasting snow. Sometimes these are high up in the mountains, as in tropical countries, and then the farther north or south we travel from the Equator the lower becomes the snow-line above which snow never melts.

When snow falls on the mountains in winter it lies there, the layer becoming thicker and thicker, but when summer returns and the warm rays of the sun shine upon the snow, much of it melts. But on the high mountains the summer heat is never strong enough to melt all the snow, and so the tops of the mountains are perpetually white.

The snow-line is very high up in some parts of the world. On the northern side of the Himalaya Mountains, for instance, it is 16,600 feet above the level of the sea, and in the Peruvian Andes it is 15,500 feet up. Then as we go north and south from these mighty mountains we find the snow-line getting nearer and nearer to the sea. In the Alps, for instance, it is 8,500 feet above sea level, and then in the Arctic and Antarctic regions it is at the very sea level itself. There all the country for tens of thousands of miles is covered with a vast layer of perpetual snow and ice.

How the Snowfall Disappears

Naturally, in the upper regions of the world's mountain ranges the snow cannot everlastingly accumulate, and much of it that is not melted by the summer sun is got rid of by avalanches or snowslides. It is estimated that about a third of the total snowfall in the St. Gothard region of the Alps disappears in this way.

Of course, the avalanche matters little in uninhabited regions, but woe betide the traveller or the village that comes within the sphere of an avalanche. A very small thing may set the snow rolling. A bird's wing as it flies past, or the noise of a cracking whip, or a human shout, and then once started the snow gathers more and more to itself as it goes till at last tens of thousands of tons may come crashing down and eventually bury a peaceful valley with all its dwellings and inhabitants. In 1901 such a slide overwhelmed a village on the Simplon Pass and killed all the people.

Avalanches may occur in summer or winter. In summer the warm winds penetrate the narrow crevices in the boundless snow slopes and dissolve much of the snow lying next to the rocks, so that the connection between the snow and the rocks is destroyed and the ground becomes slippery. Thus prepared, the slightest thing will set the snow rolling, and as it tears down the mountain it not only uproots trees and other objects that may be in its way, but causes such a compression of the air that for a great distance on either side everything is destroyed. The avalanche makes a crashing sound, which is often the first indication that it is on its way.

The popular idea of an avalanche being a great ball of snow something like a huge cauliflower rolling down the mountain, is quite wrong. In appearance the avalanche is more like a waterfall completely broken up into foam. It starts slowly and increases in speed as it travels. As the snow cascade passes over the rocky precipices it bursts into round masses of woolly foam and fluttering curls of cloud, carrying with it trees and fragments of rock, and leaving behind an unmistakable track of desolation.

Digging out the people buried by an avalanche in the Swiss Alps

The winter avalanches are known as dust avalanches and are more like very powerful snowstorms. The storm raging round the summit of the mountain heaps up great piles of fine snow, till this falls like an impenetrable cloud of dust, enveloping everything in its path and carrying away houses, men, and cattle, or burying them deep down beneath its mass. Here, again, the mere pressure of the air caused by the fall of snow dislodges blocks of stone and hurls away houses and trees on either side.

In the eighteenth century the whole village of Leukerbad in Switzerland was destroyed by an avalanche which buried the houses beneath such a mass of snow that only very few of the people buried alive were able to work their way out to daylight. One boy, Stephen Roth, was imprisoned for a whole week in a corner of a cellar. He could do nothing to break from his icy prison, but he sang hymns and psalms as loudly as he could, and was eventually heard by some energetic diggers, who freed him, but the experience he had gone through was so terrible that he died within a week. Altogether 55 human lives were destroyed in this catastrophe.

A few weeks later another avalanche occurred at Obergestelen in the Valais, when 120 houses and stables were overwhelmed and 84 people with 400 head of cattle were killed. In the last couple of hundred years many thousands of people must have been killed by avalanches in the Alps alone. The same thing, of course, occurs in other great mountain ranges, but in such mountains as the Himalayas and the Andes the loss of life is much less, as the valleys are not so populated as are the Alpine valleys.

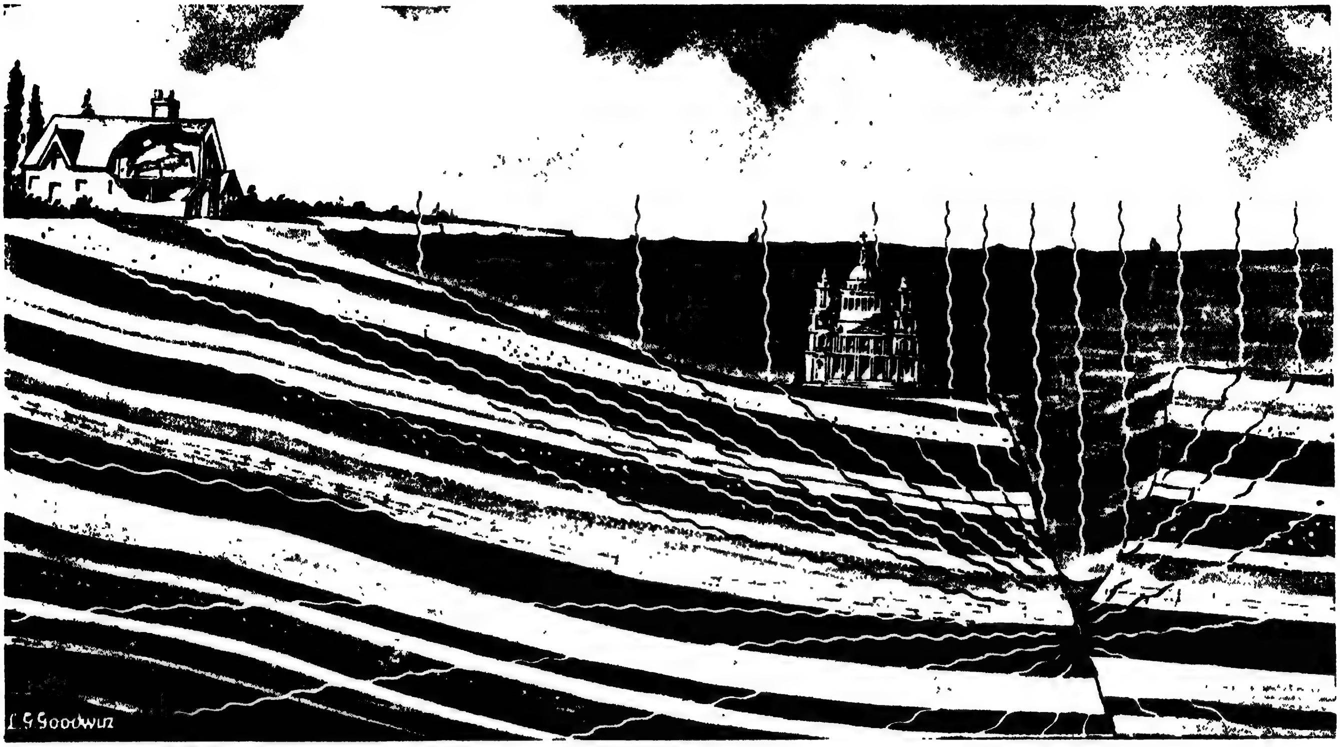
A Village Overwhelmed

When the whole village of Ruaras in the Grisons was buried by an avalanche over a hundred people were overwhelmed, but as the avalanche came down in the night when all the people were in bed the loss of life was less than it would have been had the fall occurred in the daytime. At first the people, finding everything dark, thought how interminable the night was, but at last some, getting up, discovered that the village was buried under a mountain of snow. The men got to work, and eventually sixty people were able to dig their way out.

Often the compression of the air caused by the fall of an avalanche completely uproots the trees of a forest, snapping the trunks like matches.

Of course, those areas where avalanches are pretty certain to occur are avoided by human beings. But frequently the unexpected happens, and an avalanche that falls upon a village may be the first that has occurred there in human memory.

THE WAY AN EARTHQUAKE OCCURS IN ENGLAND



Earthquakes do not happen very often in England, but from time to time they occur, and sometimes the effects are felt over a very large area. This picture shows the probable cause of such an earthquake as that of June 7th, 1931, which was felt almost everywhere in the country. In the North Sea, which is mostly so shallow that if St. Paul's were stood on the sea-bed the cross would appear above the surface of the water, there is one place with a great hole or chasm some 300 feet deep. This, it is believed, was the centre of the earthquake, and what happened was probably that beneath this hole there was a fault or crack, and the rocks for a long way down slipped. That jerked the Earth's crust, and waves or vibrations were sent in all directions, as shown in the picture, shaking people in their beds, rattling crockery, and so on. Where the vibrations reached the sea they would be transmitted upwards, as shown here.

WHERE EAST MEETS WEST

In the grounds of Greenwich Observatory is a tablet marked "Greenwich Meridian," and scientists imagine a line going

The Meridian mark at Greenwich

round the whole Earth passing through this spot. That half of the line or circle on our side of the Earth is known as the Meridian of Greenwich. The word meridian is sometimes used for the whole circle and sometimes for only half the circle.

It is here that East really meets West and as you stand upon the line facing the tablet and looking North, everything seen on your right-hand is East and everything on the left-hand is West. You can stand with one foot in the East and the other foot in the West.

As the Earth turns round the Sun rises in the East till it reaches its greatest height above the meridian and then it gradually sinks into the West and disappears. When it is at its greatest height above the meridian the time is midday; in fact, the word "meridian" really means midday, and, in addition to being the name of this imaginary line on the Earth's surface, it is also the name given to an imaginary line in the heavens exactly above the geographical meridian.

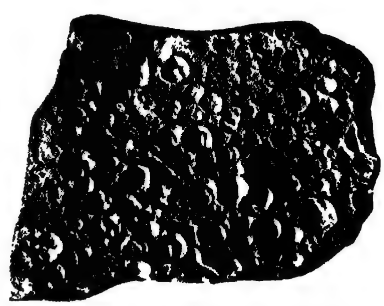
If the Earth were a perfect globe the meridian would be an exact circle, but as the Earth is somewhat flattened at the Poles, the meridian is not a circle but an ellipse.

As a result, when the meridian circle is marked off into 360 degrees by the parallels of latitude, those imaginary lines going round the Earth parallel to the Equator, the divisions or degrees become shorter as we approach the equator and longer as we travel towards the poles.

RAIN-MARKS A MILLION YEARS OLD

It is a marvellous thing that we can hold in our hands a piece of stone pitted with the marks of raindrops that fell a million or more years ago. Not only so, but by the fact that one side of the impression is deeper than the other, we can tell in which direction the rain fell and the wind was blowing.

On a muddy beach in the far distant past, at low tide a rainstorm came on and the



The imprints of ancient raindrops

impressions were left in the mud. Then the Sun shone upon the mud and dried it hard. On the return of the tide these marks were filled up with fresh mud. Later on the whole beach was raised above the level of the sea, and now, when we are digging, we come across the imprints.

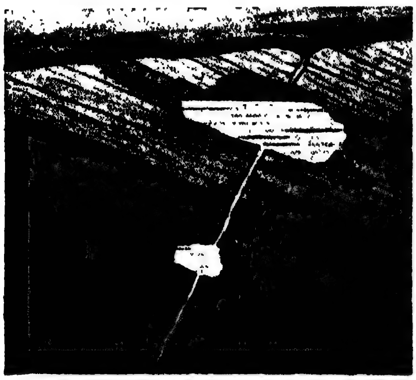
HOW LONDON HAS RISEN THROUGH THE AGES

Cities and towns in the past have had a habit of constantly getting buried. Wastage and rubbish accumulated without being cleared away, as it is in these days, and when a new road or a new building was wanted it was made on top of the rubbish, and what was there before became buried. It is really fortunate for us that this was the case in old days, for, as a result, we are able to dig down in London and other cities and find many fascinating and interesting things that belonged to our ancestors. The tendency of cities to become buried is manifest even to-day. In the older parts of our big towns we frequently have to step down from the street level into a shop or house, because the road, as the years have gone by, has been made up higher and higher. In London we can dig down and come to the remains of the Saxon city, then to Roman London, and still lower down we find the remains of the Stone Age men. If with a giant cheese slice we could cut right down through the City of London and open up a complete section we should see something like this picture, drawn by Mr. L. G. Goodwin. The successive layers as London has risen age by age would appear before our eyes.

THE STORY OF HOW THE CAVES WERE FORMED

In many parts of England and other countries there are series of caves, generally in limestone rock. In some cases these caves may extend for miles, and are found one below the other decorated and festooned with stalactites and stalagmites, which are like icicles and pillars made of rock. Such caves are always a great attraction to holiday-makers, who like to visit them and wander through their fantastic chambers. The story of how the caves were formed is an interesting one.

A fault or crack enables water to percolate through the strata



Chemicals in the water eat away the rock so that pockets and caves are formed

First of all the rocks cracked, perhaps through an earthquake. This made an opening through which water percolated and, as it trickled down the crack, gradually dissolved the material of the rock until the crack became wider.

At certain parts of the crack the water accumulated and dissolved more and more of the rock until a little opening was formed. Here the water gathered and ate away the hard material till the first cave was excavated

The Toll of the Trickling Water

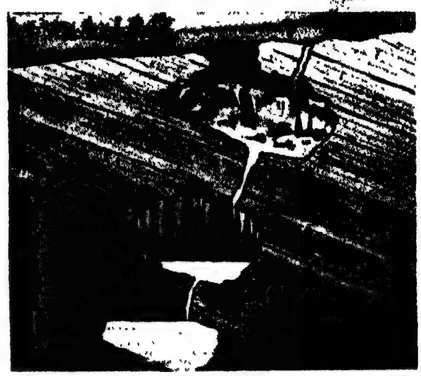
But the water went on trickling down the crack and began another cave lower down, and still later on another. The upper caves became bigger and bigger, and as the water, with the rock material dissolved in it, dripped from the roof and evaporated, it left a small portion of the rock on the spot it fell from.

The remainder of the water on reaching the floor also evaporated, leaving a tiny portion of rock. This having gone on for thousands of years led to the formation of the stalactites or hanging tails of rock suspended from the roof and the stalagmites or pointed pillars of rock standing up from the floor

Pure water does not easily dissolve mineral matter, but when rain falls to the earth it is not pure, for in passing through the atmosphere it dissolves some of the gases in the air and then as it percolates through the soil it takes up other matter, and is then capable of dissolving mineral matter.

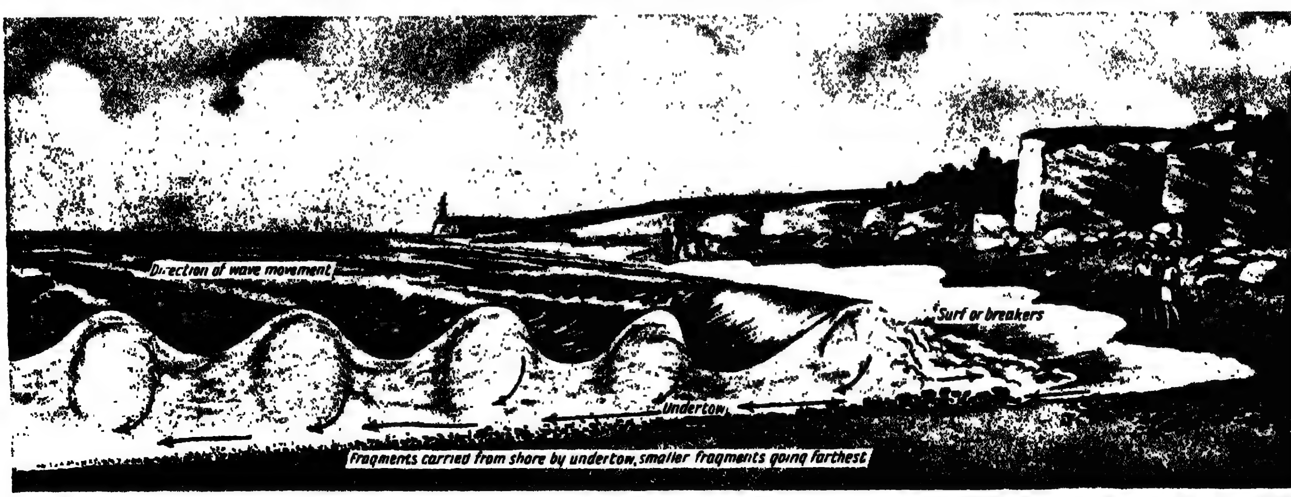
Limestone is the most soluble of all the common rocks, and that is why most of the big caves that are found are in limestone. In the Mammoth Cave of Kentucky there are over 200 miles of passage-ways and many large chambers.

3 The caves increase in size and number and stalactites and stalagmites form



The caves continue to increase, and the roof of the top one falls in

WHAT HAPPENS WHEN THE WAVES REACH THE SHORE



This picture shows us exactly what happens to the waves of the sea when they reach the shore. These waves are caused by the wind blowing on the surface of the sea, but as they get to where the beach slopes up the bottom interferes with them, and they grow higher in proportion to their length. The front becomes steeper until at last it topples over and the water is hurled forward as surf or breakers. These breakers strike the shore with great force, and then the water begins to flow back along the bottom, forming a current or undertow so strong that it is often a danger to bathers, who are caught by it and held under water. As the water flows back it carries with it rocky fragments of various sizes which have fallen from the cliffs, the larger fragments being dropped first and the smaller ones being carried a considerable distance from the shore.

THE MYSTERIES OF BALANCE

Children who build houses with toy bricks know how difficult it is when the building gets high to preserve the balance so that the bricks will not fall over. It is difficult, too, at first, to learn to ride a bicycle. We seem top-heavy and fall so easily. The mysteries of balance are very interesting, and here we read something about them.

It is quite easy for us in the ordinary way to maintain our balance and remain upright. But sometimes when we are reaching for a thing we overbalance and fall. That is why it is always very foolish to lean out of a window. We never know exactly when our balance will be lost and, if we are leaning forward and our feet slip a little, we may quickly overbalance and fall out.

What exactly is it that enables us to keep our balance and what is it that causes us at times to overbalance? How is it that most of us find it very difficult to walk with a book balanced on our head, while some men, like those fruit porters at Covent Garden Market in London, can walk and carry a dozen or more baskets on their heads without letting them fall? To understand these things we must know something about the mysteries of balance.

Take an ordinary whipping top and stand it on the ground with the peg uppermost. It will remain in that position unless somebody gives it a hard knock. It is what we call in stable equilibrium. Equilibrium is a long and difficult word, but it comes from two Latin words meaning "equal" and "balance," and "equilibrium" means "evenly balanced."

Three States of Balance

Now let us take the whipping top and balance it on the point of the peg. It will be exceedingly difficult to do this, and if we do succeed, the least touch or puff of air will cause it to fall over. When balanced on the peg the top is said to be in unstable equilibrium.

Make a third experiment and lay the top on its side. It will remain still unless the wind blows it or somebody touches it, when it will roll along for a certain distance and then rest in a similar position on its side. This state is said to be one of neutral equilibrium.

Now what do these three terms really mean? Well, before we can understand, we must know something about the force of gravitation, that is, the pull which the earth exerts upon everything on its surface.

Take a rod. This rod is made up of a number of small particles, and the earth pulls every one of these towards its centre. But as the various particles are held together in the rod by a force which is known as cohesion, there is one point in the rod where the earth's pull on the various particles may be said to be concentrated. This point is known as the centre of gravity.

Every object or body has a centre of gravity, and it is the spot where the body can be balanced if it is rested on a point, or if it is suspended from a string.

We may test this for ourselves by taking a piece of cardboard. Suspend it from any point, and when it comes to rest, draw a continuation of the string as a straight line on the cardboard. Now suspend the same piece of cardboard from any other point, and when it comes to rest, again draw a continuation of the string. The place where the two straight lines cross will mark the centre of gravity.

Of course, if the card has any substantial thickness, the centre of gravity is inside its substance, but if we take a thin piece of cardboard the thickness does not matter, and by placing the point where the lines cross on the point of a pin or needle held vertically, we can balance the cardboard. No matter what shape the card may be, we can always find the centre of gravity in this way.

This cart can travel safely on the slope because a line from its centre of gravity falls within its base as shown

A slight push or jolt will capsize the same cart now that it is loaded because a line from its centre of gravity falls outside its base

The centre of gravity of a solid body, such, for instance, as an apple or orange, can be found by suspending it in three places and sticking pins through the fruit in continuation of the string. The point where the three pins cross inside the orange or apple will be its centre of gravity.

Here we must note one rather curious fact. It is that in some bodies the centre of gravity is not within the substance at all. This is the case, for example, with a ring. Its centre of gravity is somewhere within the space which the ring encircles.

Toys that Teach

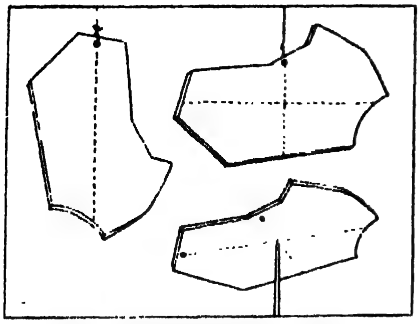
Let us come back to the question of equilibrium.

A body is in stable equilibrium when it tends to return to its original position if it is slightly tipped out of that position; or in other words, it is in stable equilibrium if tipping it slightly tends to raise its centre of gravity. It is in unstable equilibrium if a slight tipping causes it to move from its original position, or in other words, if a slight tipping lowers its centre of gravity.

The body is in neutral equilibrium when a slight displacement neither raises nor lowers the centre of gravity and the body after displacement neither returns to its original position nor moves farther from it. The higher the centre of gravity is over the point of support of the body, the more unstable it is.

There is a children's toy which consists of a body made of some light substance, such as cork, with a piece of lead attached to one of its extremities. If the body be placed on the light end it will immediately invert its position. The body is usually painted outside in the form of a man, and if he is stood on his head he at once turns over and comes to rest upright on his feet, the reason being, of course, that the piece of lead is where the feet are, and the body brings itself to rest in a state of stable equilibrium.

Another well-known toy is a balancing man, to which is attached a bent rod with weights at the ends. The man can be easily balanced on the point of a finger because the weights at the ends



How to find the centre of gravity

of the rod bring the centre of gravity below the point of support, and the figure is then in a state of stable equilibrium. It is this principle that enables a tight-rope walker to keep upright as he walks along the rope with a long rod heavily weighted at the ends. Without the rod he would not be able to keep his balance.

Motor-buses are so constructed that the bulk of the weight is low down, near the axles of the wheels. The bus with its double deck may look very top-heavy, but with the centre of gravity so low down it is not really so. Tilting tests are carried out when the buses are built, and it is astonishing at what a sharp angle the bus can lean over without falling completely on its side.

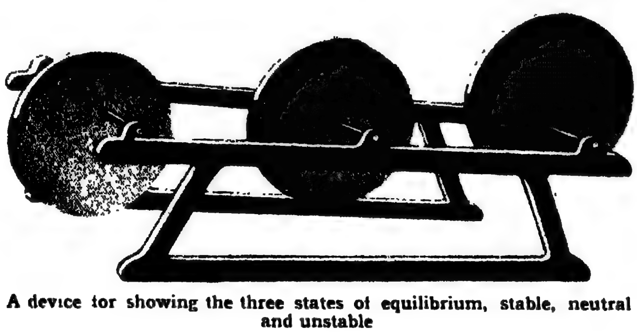
A vertical line drawn from the centre of gravity is called its line of direction, and the position of this line has an important relation to the stability of the body. If it fall within the base, the body will remain firm. But if the line fall outside the base the body will turn over. This is the principle carried out in constructing and testing buses.

It also explains why when we carry a heavy load on our shoulders or in one hand we lean forward or to the side. We do this to place the combined centre of gravity of ourselves and the load in a stable position.

Of course, the lower down in a body the centre of gravity is the more likely is a line drawn from that centre in the direction of the Earth's centre to fall within the base of the body. That is why very often a vehicle that can travel empty on a slanting hillside with perfect safety is liable to topple over if it is loaded with goods that reach very high up. The goods naturally raise the centre of gravity of the vehicle with its load, and the line of direction now falls outside the wheels. A slight jerk or push will overturn the whole concern.

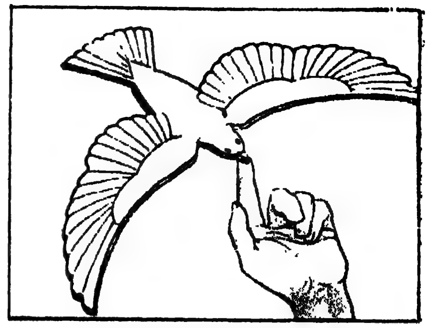
A ship caught in a squall at sea will often capsize if it has not sufficient ballast in its hold. That is why a vessel, rather than travel home empty, if it cannot get a cargo will take in stones as ballast. The centre of gravity is then brought low in the vessel and, like the child's toy consisting of a little man which when knocked over regains his upright position, it easily recovers as it is swayed up and down by the wind and waves.

The little man who stands upright on the tip of your finger. The weights at the ends of the rod place his centre of gravity below his feet



A device for showing the three states of equilibrium, stable, neutral and unstable

Steamboats loaded with passengers have been capsized before now by all the people on deck rushing to one side to see something, and thereby changing the centre of gravity of the vessel. Something like that happened in the case of the warship Royal George, which capsized at Spithead on August 29th, 1782, with the loss of nearly 800 lives. The vessel had been heaved over on one side by running all her guns to that side, so that a leak on the bottom of the vessel might be repaired. Suddenly the wind caught the ship and, being in unstable equilibrium, she was in a moment turned right over. Her portholes were open, and the water rushed in and she sank.

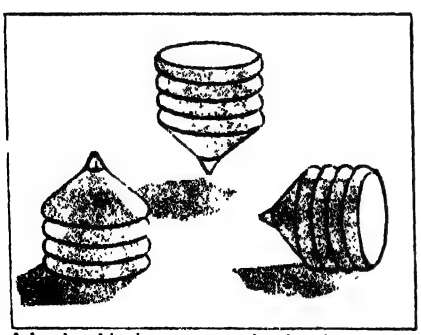


The bird that balances on its beak

Accidents in rowing boats brought about by people standing up to change places are also caused by neglecting the principles of balance. Here, again, the centre of gravity is raised, and it does not take much to overturn the boat.

The mason and bricklayer are very careful to observe the laws of balance when they are erecting a building, and may be constantly seen using the plumb-line to be sure that the wall is straight. If it leaned inward or outward it would be liable to tumble over, like the porter's pile of baskets. The famous Tower of Pisa in Italy, which is 190 feet high, leans about 12 feet out of the perpendicular at the top, but it does not fall because the line of direction is still within the base. The same is true of another leaning tower at Bologna.

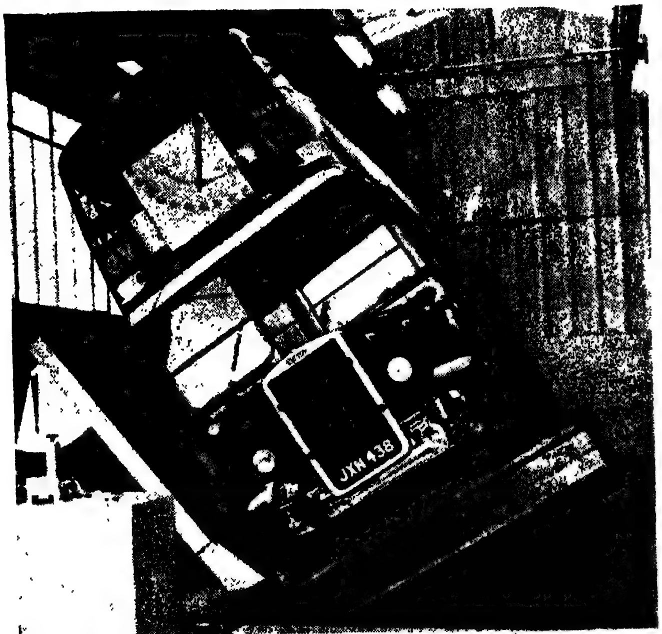
When we walk on stilts we raise our centre of gravity, and so the walking is much more difficult than when we are on our feet on the ground. A person who stands on one leg usually holds the other one out behind or in front and inclines his body so as to adjust his centre of gravity. The swaying motion of the body in walking is due to the fact that as we change the base from one foot to another we must adjust our centre of gravity to keep our balance.



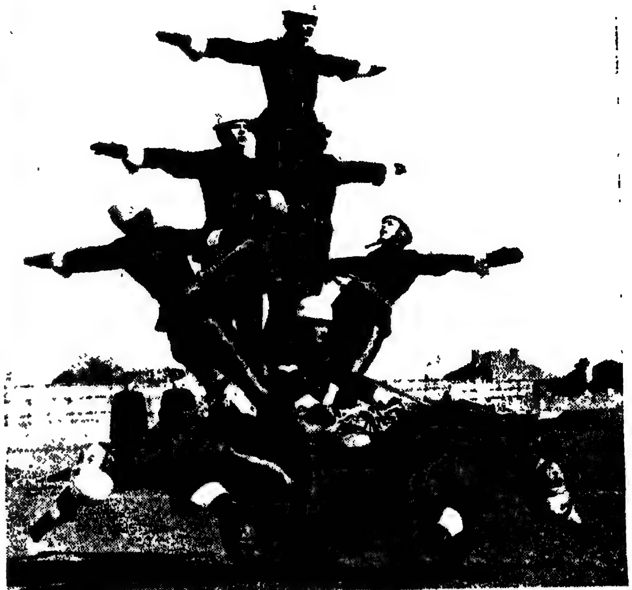
A boy's whipping-top seen in the three states of equilibrium

These boys carrying burdens have to bend to get into stable equilibrium

THREE STRIKING EXAMPLES OF BALANCE



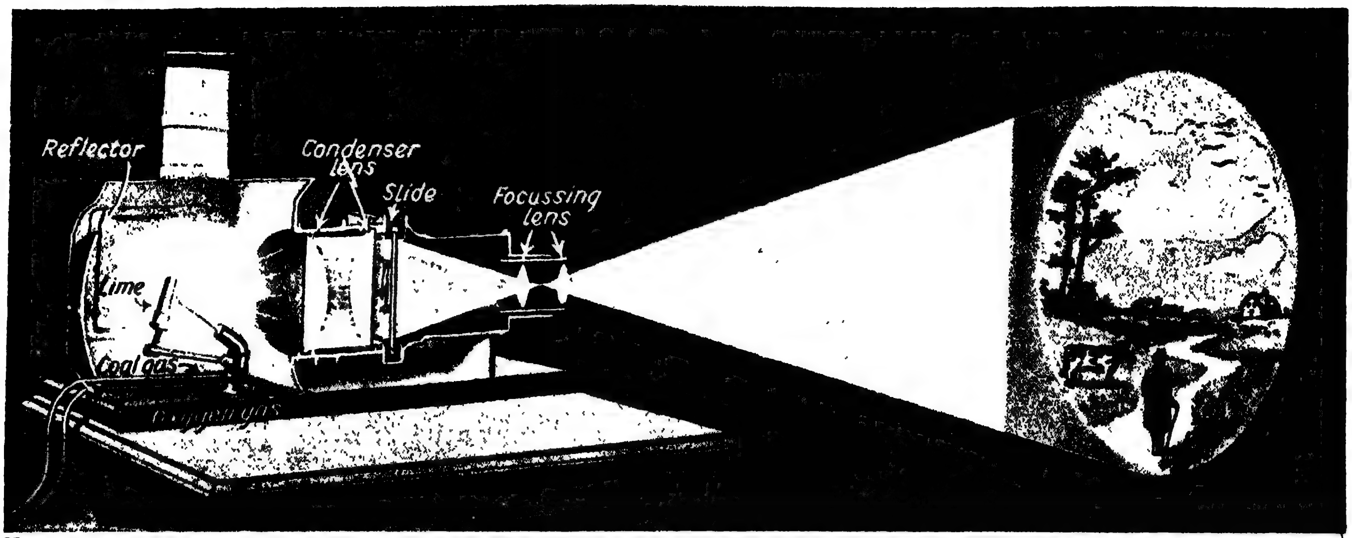
A double-decked bus with a covered top looks very top-heavy, but the great weight of the machinery in the bottom of the bus keeps the centre of gravity quite low. The result is that the bus has got to lean over very much indeed for a line drawn from the vehicle's centre of gravity direct to the earth to fall outside the base. Only then would it topple over. All buses are tested as shown here, to be sure that their centre of gravity is low enough. The pointer and dial show the centre of gravity relative to the tilting angle



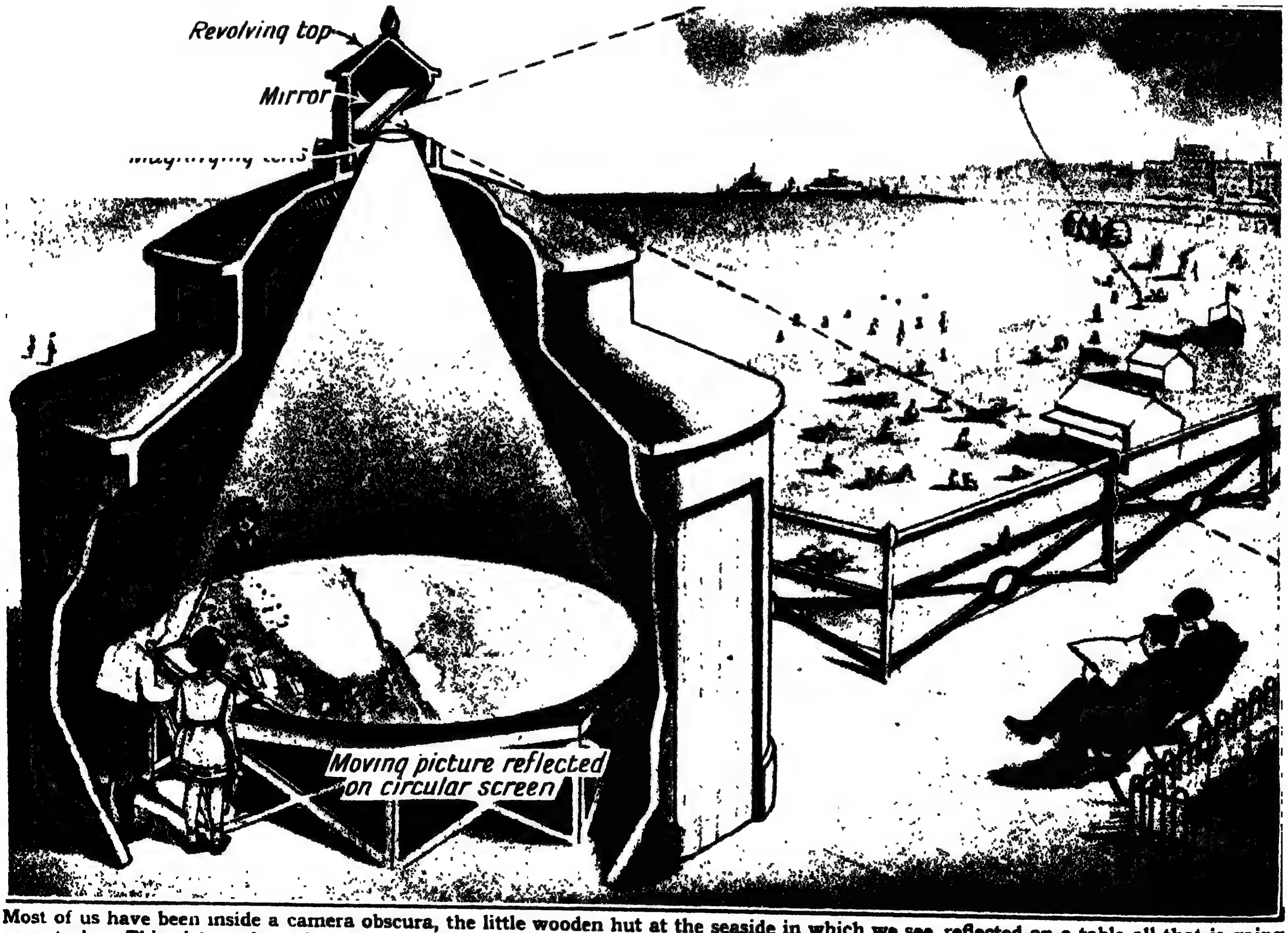
Here is a difficult feat of balancing. Ten despatch riders of the British Army's Royal Corps of Signals are mounted on one motor cycle, some of then hanging over the sides, front, and rear. It is much easier for them to retain their balance when the bicycle is moving quickly than when it is going slowly, as the greater their speed on the cycle the less the power of gravitation upon their bodies. The heavier the motor cycle engine, the easier is the feat, because the lower is the centre of gravity

The porters of Covent Garden and other markets have regular competitions to see which of them can carry the greatest number of fruit baskets without dropping any. Of course, the taller the pile the more difficult is the feat, for as the height of the pile grows the centre of gravity of the baskets and the man carrying them is raised, and the tendency for the pile to fall over is increased. Success comes to the man who is best able to keep the pile of baskets upright. Once they begin to sway so that the centre of gravity of the pile falls outside the base of the man's feet, the greater chance there is of a collapse, though sometimes a fall is prevented by the cohesion between the baskets. Only those who have tried to carry such lofty piles of baskets realise how difficult the feat really is

TWO OPTICAL INSTRUMENTS EXPLAINED



Here we see how the magic lantern throws an enlarged picture of the slide on the screen. The lantern is a dark box containing a light. In this case a limelight is shown, where a flame of coal-gas intensified by having a jet of oxygen directed upon it is made to heat a cylinder of lime to incandescence. A reflector concentrates the light. In front of the box is a large lens or combination of lenses known as a condenser, and its work is to arrest the diverging rays of light from the lime and direct them upon the slide. In front of the slide is a double tube containing one or more focussing lenses, and light from each point of the slide passes through the focussing lenses and throws an inverted image of the slide upon the screen. A lantern slide is always put in upside down, so that it may appear the right way up to the spectators. To get the picture clear, the tube containing the lenses is slid in or out in order to focus the rays



Most of us have been inside a camera obscura, the little wooden hut at the seaside in which we see reflected on a table all that is going on outside. This picture shows how the moving picture is obtained. In the roof of the hut is a mirror placed at an angle of 45 degrees, which catches a reflection of the scene outside. This is directed on to a lens through which the light passes and it is then thrown upon a screen of white paper on a circular table. The part of the roof containing the mirror and lens can be rotated by pulling a string, and thus we are able in turn to see what is going on right round the hut. The room containing the table on which the image is thrown must be in total darkness, except for the light received through the lens. **Camera obscura means dark room**

ROMANCE of BRITISH HISTORY

THE MYSTERY OF THE RED KING'S DEATH

Who shot the arrow that laid low William Rufus, the second of the Norman Kings of England? He was hunting one day in the New Forest when an arrow pierced his breast, and his companion, Walter Tyrrell, galloped off with all speed to the sea-coast and took boat for Normandy. The story that became current was that Tyrrell, in shooting at a stag, had killed the King by accident, but rumours were not wanting that William's brother Henry had had something to do with the death. Here is the story of this mystery of the New Forest.

William the Conqueror was a hard and cruel king. He had oppressed the English, and it was through his cruelty that he met his death in Normandy.

Stung by a joking insult of the French king, Philip, he determined to take a terrible vengeance, and gathering an army marched into France. The wheat fields were ripe and ready for cutting, and the trees were loaded with fruit. William ordered his soldiers to destroy everything as they marched. He sent his cavalry to trample down the corn-fields and ordered his foot soldiers to tear up the vines and cut down the fruit trees.

When he came to the first town on his route, which was Mantes, he had it set on fire and then went to the scene of the tragedy to feast his eyes on the spectacle.

The King's Horse Stumbles

But retribution overtook him. As he was galloping over the ruins his horse stepped upon some burning timber concealed by ashes, and stumbled. The King, in his fall, was injured, and as he was tired with riding and shouting and suffering from the heat of the fire, the wound proved dangerous, and it was not long before he had to be carried back to Rouen.

He became worse, so bad, indeed, that he could not endure the noise of the city, and so was taken to a monastery outside the walls, where he could be quiet. Doctors and priests did all they could to minister to his body and soul, but finding he grew worse rather than better, William began to feel remorse and sent large sums of money to rebuild the churches of Mantes which he had burned.

He also sent money to the monasteries of England for distribution among the poor, and to make up to some extent for the many robberies he had committed in the conquered country. Many of the Saxon English who were languishing in prison were set at liberty by his orders.

But it was all no use. The King became worse, and his sons and followers urged him to make his will. He had quarrelled with his eldest son, Robert, who was absent from the bedside, but he had already bequeathed the dukedom of Normandy to him and made no attempt to disinherit him of this.

"As for the Kingdom of England," he said, "I bequeath the inheritance of it to no one, for the inheritance thereof was not bequeathed to me. I acquired it by force and at the cost of blood. I leave it in the hands of God, only wishing that my son William, who has been submissive to me in all things, may obtain it if he please God and prosper."

"And what do you give me, father?" asked his youngest son, Henry.

A workman arrived with six new arrows for the King

"I give thee," replied the King, "five thousand pounds of silver from my treasury."

"But what shall I do with this silver if I have neither land nor home?"

"Be quiet, my son, and trust in God. Let thy elder brothers go before thee. Thy turn will come after theirs."

Thereupon Henry left the bedside to make sure of his five thousand pounds of silver. He was very careful to have the metal weighed, and then placed the money in a strong chest with plates of iron and good locks on it.

William, without waiting for his father's death, rushed off to England to make sure of the crown. Everyone called him Rufus, or the Red, because of his very red face. His hair was not red, but yellow.

At last, as the sun was rising on a September morning and painting the sky with its glory, William the Conqueror was awakened by the sound of bells, and asked what they meant. He was told that they were ringing for the early morning service in St. Mary's Church, and hearing this he lifted up his hands, now very feeble, and exclaimed: "I commend myself to my Lady Mary." Then he instantly fell back dead.

Nobody worried about the great Conqueror now. The doctors and courtiers hastily mounted their horses and rode off to look after their own interests. The servants ransacked the place for arms, clothes, vessels, and other articles, and also fled. The great Conqueror's body was left lying on the floor for several hours.

A Voice Rings Out

At last some of the clergy approached the body with crosses and censers, and praying for the soul of the dead man, conveyed his body to Caen, where it was buried in the Church of St. Stephen.

But even in death the Conqueror was not to have peace, for at the funeral while the service was going on a loud voice rang out: "Clerks and Bishops, this ground is mine; upon it stood the house of my father. The man for whom you pray wrested it from me to build thereon his church. I have neither sold my land nor mortgaged it, nor have I forfeited it, nor made any grant whatsoever of it. It is mine by right and I claim it. In the name of God I forbid you to lay the body of the spoiler therein or to cover it with my soil."

The speaker was one Asselin, and many present confirmed the truth of his words. The bishops suspended their service and made a bargain with the man to pay him a fair price for the ground. Then the funeral went on, and the Conqueror's body disappeared from sight.

William Rufus, on his way to England, was overtaken and informed of his father's death. The news did not worry him. He hurried off to Winchester, where the royal treasure lay, and gaining over by his promises the keeper of the Treasury, he obtained possession of the keys. The Treasury was found to consist of sixty thousand pounds of silver with a large quantity of gold and jewels.

William called together the powerful Norman barons who happened to be in England at the time, and told them of the Conqueror's death, persuading them to choose him as King. He was at once anointed in Winchester Cathedral by Lanfranc, the Archbishop of Canterbury, and thus it came about that while several Norman barons across the water were holding a council to decide who should be King of England, William had already seized the crown of that realm.

If possession is nine points of the law, William had certainly established his legal rights.

False Promises

He made a very bad start as a king by sending to prison once more a number of Saxon nobles whom his father had recently restored to liberty, but when he knew that the Norman barons across the Channel had decided to depose him and to place on the throne his elder brother, Duke Robert of Normandy, he changed his tone and promised his English subjects, both Norman and Saxon, all sorts of things if they would rally round him and help to defeat his enemies.

He restored to the Saxons the right of bearing arms, gave them back their ancient forest privileges, and stopped levying the Poll Tax and other tributes which had been very oppressive and odious.

Thirty thousand Englishmen rallied round the Red King and were given arms, and these, together with his Norman knights on horseback, he led against the town of Rochester, held by Robert's friends. The town soon surrendered, but having defeated his enemies William came to terms with his brother Robert, who agreed to give up the English throne, and then William showed his true character.

He withdrew all his promises to the Saxon English and once more treated them with cruel oppression. Wherever he passed in his journey through England his servants and soldiers ravaged the country.

When they could not eat all the provisions which they found in the houses of the English, they compelled the owners to carry them to the nearest market and sell them, and they seized the money that was realised. At other times they would burn the food as a pastime, and when they found more drink than they could consume

Just as the King was about to start off a monk arrived with a letter from the Abbot

they used to wash their horses' feet and legs in it.

"Their ill-usage of the fathers of families, their insults to the wives and daughters," says an old historian, "were too shameful to relate, so that on the first rumour of the King's approach everyone would fly from his dwelling and retreat with whatever he could save to the depths of the forests and into desert places."

Fifty Saxons, who by serving the King had retained some of their old possessions, were accused of having hunted in the Royal Forests and of eating the King's deer. They denied the charge, but were made to undergo the ordeal of heated irons, that is, their hands were burned and then bound up for several days. When they were unbound, if they showed no sign of the burning, that would be regarded as a definite proof that the prisoners were innocent. "Sure enough," so the old chronicle says, "when the bandages were removed the hands were uninjured."

But William cared nothing for this test. When it was related that after three days the hands of all the accused had appeared unseared, he exclaimed, "What about it? God is no judge of these matters. Such affairs concern me alone. It is I who must judge therein." Is it any wonder that this King was hated, even more than his father?

Yet the Saxon English were helpless, and the only revenge they could take was to style him in derision "The Keeper of the Woods and of the Deer."

All sorts of stories grew up about the curse that fell on Normans who hunted in the New Forest. It was declared that the Evil One under various forms appeared there and that he had a terrible fate in store for the King and his counsellors.

The Monk's Warning

And strangely it came, on a July day, while he was hunting in the New Forest of fateful memory. On the morning of the day he, with a number of his favourites, ate a great meal in the castle of Winchester before setting out for the chase. While the King was tying on his hose and joking with his friends, a workman arrived with six new arrows which had been ordered.

William examined them, praised the workmanship, and keeping four for himself, gave the other two arrows to Sir Walter Tyrrell, saying laughingly, "A good marksman should have good arrows."

Walter Tyrrell was a French knight who owned large lands in the country of Poix and in Ponthieu. He was the King's greatest friend, if such a man as William Rufus can be said to have had any friends at all, and certainly he was the monarch's closest attendant.

Just as the hunting party was setting out a monk of St. Peter's Monastery at Gloucester rode up and put into William's hands a letter from his Abbot. The Abbot, a man of Norman birth, sent word to the King that one of his monks had had in his sleep a dream which had caused him some concern. The monk declared that he had seen the Saviour sitting on a throne and at his feet a woman supplicating him. "Oh, Saviour of the world," said she, "look down with pity on Thy people groaning under the yoke of King William."

The Abbot thought the matter of

such importance that he felt he had to send word of what had happened to the King. William, however, was not upset. He roared with laughter, and cried out, "Do they take me for an Englishman with their visions? Do they think me one of those fools who leave their business and change their course because an old woman dreams or sneezes? Come on, Walter, let us be off."

In the King's party were his brother Henry and several lords, besides Tyrrell, but soon after reaching the forest the party broke up and only Walter Tyrrell remained with the King. According to the story which was afterwards told the two men took up their stations opposite each other. Each had an arrow on his cross bow with his finger on the trigger.

Suddenly a large stag, driven by the beaters, advanced between the King and his friend. William let fly, but his bow-string broke and the shaft sped no distance. The stag, possibly frightened by the sound, stood still and looked around.

The King, anxious that it should not escape, made a signal to his companion to shoot, but the latter did not fire, either not seeing the stag or not understanding the signal.

William in his impatience, called out, "Shoot, Walter, shoot," and instantly an arrow entered the King's breast.

"Shoot, Walter, shoot!" cried the King

A Hurried Flight

Who had fired it? It may have been Walter Tyrell, or it may have been someone else. It may have been an accident, or the arrow may have been shot by design. Whatever is the truth about that, the King fell to the ground without uttering a sound. He was dead.

They say that Walter Tyrrell ran in haste to the King, but, finding that he did not breathe, he at once remounted his horse and galloped with all speed to the sea coast. There, taking boat, he went across to Normandy before the news could reach that country, and then passed rapidly into French territory, where he would be out of reach of William's friends.

Soon other members of the hunting party learned what had happened, but they had no concern for the dead King. What they wanted to do was to look after their own interests, and all of them, including the King's brother Henry, quitted the forest with all speed. Henry rushed off to Winchester to secure the royal treasure, and the body of William Rufus lay unattended on the ground in the forest just as his father's body had lain deserted in the monastery at Rouen.

Towards evening some charcoal-burners returning to their homes came upon the body of the King with the arrow still in the wound. Wrapping some old cloths round it they placed the body on their rough cart and trudged off towards the castle of Winchester, the blood dripping along the road as they went. In this unroyal way did the body of the second Norman king go to its funeral.

Henry had already arrived at the castle, where he was demanding the keys of the Royal Treasury. The keepers knew not what to do. If William were not dead, it would be as much as their lives were worth to hand over the keys to his brother. On the other hand, if he were dead and Henry succeeded him, it was as much as their lives were worth not to give him the keys. The matter was complicated by the fact that, according to arrangements of long standing, Robert, the elder brother, was to succeed William on the throne of England.

While the keepers were thus hesitating a Norman knight, William de Breteuil, arrived in breathless haste from the New Forest and began to oppose the demand of Henry.

"Both you and I," said he, "are loyal. Bear in mind the faith we have promised to Duke Robert, your brother. He received our oaths and our homage, and whether present or absent he has the right."

But Robert had gone off to a Crusade in the Holy Land, and, although he was returning, had not yet reached Normandy. As a matter of fact, he was dallying at a Norman castle in Italy.

A fierce quarrel ensued among the Normans at Winchester, but Henry, who was a man of action, drew his sword and, with the aid of a number of friends, soon got possession of the royal treasure and the regalia.

Robert's partisans, owing to his absence, could make no headway against the friends of Henry, who hurried off to London and persuaded the Normans assembled there to choose him as king. He was popular with the clergy, who soon crowned him, and as Henry had been born in England the Saxon English preferred him to his brother Robert; and when at his Coronation he promised to observe the good laws of King Edward the Confessor, they gave him their support.

Meanwhile, what had happened to the Red King's remains? He was loved by none, and his private and public conduct had often drawn forth the condemnation of the Church, although he had never actually been excommunicated. Out of reverence for the royal dignity, however, the remains were buried in Winchester Cathedral, just under the Central Tower, but no religious service was held.

An Unsolved Mystery

It was a strange end for a king. There was no Mass, no bell was tolled, and no offerings were made by his brother or his friends for his soul. When, seven years later, the cathedral tower fell with a crash, the popular belief that the monarch who lay buried beneath it had been unfitted for Christian burial was confirmed.

The great mystery of his death can never be solved. Did Walter Tyrrell shoot the King either by accident or design? It is said that he himself denied this. There is no proof that if he shot at the stag it was his arrow that pierced the King.

Hated by all, it was quite possible that some unknown person may have aimed the arrow which pierced the King's breast. Some have even hinted darkly that William's brother Henry had something to do with the tragedy. He was certainly in the forest at the time. Whatever the truth, there is no doubt that everyone was glad when it was known that William Rufus was dead.

MYRIADS OF GLOWING SUNS IN DISTANT SPACE

On any fine moonless night when we look up into the sky we see that faint band of cloudy light passing across the sky which we call the Milky Way. It was given that name because the men of old, not knowing what it was, weaved a story about a stream of milk being spilt in the sky. Powerful telescopes and other instruments have shown us what the Milky Way really is. It consists of a vast system of glowing suns, most of them far bigger than our Sun. It is the universe to which our solar system belongs, and by means of the great 100-inch telescope at Mount Wilson Observatory in California, by whose courtesy this photograph is given, about 1,500 million stars in the Milky Way can be photographed. Here is part of the Milky Way near the constellation Sagittarius, or the Archer

THE VASTNESS OF DISTANT SPACE

Is there such a thing anywhere in the universe as empty space? Men of science used to believe there was, but they have now come to the conclusion that nowhere, not even in the most distant space, is there such a thing as real emptiness. Yet the countless millions of stars are so far apart that there is little likelihood of their coming into collision. In these pages we read some graphic facts about the marvels of distant space

We often speak of an empty room, or an empty box, or an empty bottle; but, of course, these things are not really empty as they contain air. By means of an air pump we can, of course, extract air from a vessel; but, however much we pump, we cannot draw all the air out. There is always a small fraction left inside the vessel, so that no box or bottle can ever be really empty.

When we come to distant Space, the vast regions that lie between the stars, things are different. The more we study the heavens, the more bewildered we become by the apparent contradictions. A person with perfect eyesight looking up on a clear night from the British Isles, can see rather more than 3,000 stars. If he travels to Australia and looks up, he can see more than 3,000 other stars that were not visible in the Northern Hemisphere.

Altogether, with the naked eye, we can see from the Earth, if we have very good eyesight, 7,647 stars. But, of course, a powerful telescope shows many millions more, and the camera can record more than the human eye. By means of a camera attached to the 200-inch telescope at Mount Palomar Observatory, California, for instance, nearly 2,000 million stars can be photographed, while there are millions more known to exist but as yet invisible.

Now in the heavens there are many universes of stars, and the one to which our Sun and its family, including the Earth, belong is known as the Galactic or Milky Way: the band of dim light seen right across the heavens from horizon to horizon, and made up of an incredible number of stars or suns.

One astronomer, Dr. Shapley of Mount Wilson Observatory, estimated 100,000 million stars in this system, but according to other astronomers there are probably not more than 50,000 millions. If we take the latter figure, then the number is equal to nearly 27 stars for every person living in the world to-day.

Yet, as Sir James Jeans says, the Galactic system "no more contains all the stars in Space than one house contains all the inhabitants of Great Britain. There are millions of other houses and millions of other families of stars." What an amazing thought!

With so many millions of stars, we might think that Space was crowded; but, as we see on page 42, it is really emptier than anything we can imagine. It is no more crowded than Europe would be if the only living creatures in that continent were three wasps! The reason for this is that Space is so incredibly vast.

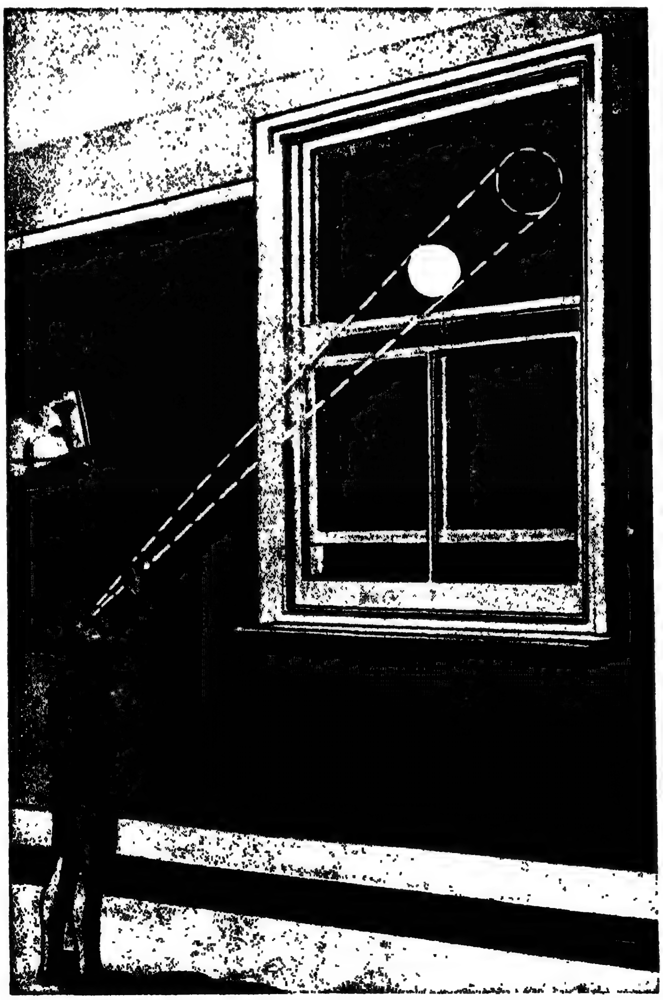
It is no use speaking of the distance of the stars in miles, for the numbers would be too large, so astronomers always reckon these great distances in light-years, a light-year being the distance that light travels in a year.

The speed of light is about 186,000 miles per second, so a light-year is 5,876,068,880,000 miles.

Now the nearest star, one seen in the Southern Hemisphere and known as Proxima Centauri, is about four and a quarter light-years distant from us, or 25 million million miles. There are, however, stars which are tens of thousands of light-years away, and beyond those others still more distant. Every increase in the power of the telescope enables still larger numbers of distant stars to be photographed.

The Milky Way, to the naked eye, looks like a blur of fog, but when it is photographed through the great telescope at Mount Palomar we see that it is made up of individual stars. They appear only as points of light, but most of them are far bigger and brighter than our Sun. It is distance that makes them appear so small.

Of course, we know from our experience in everyday life that a big thing appears very small when it is a long way off, and a small thing may appear big when it is close to our eye. For instance, if we stand at the window on a moonlight night when a full moon is shining and hold a halfpenny up an inch or two from our eye, the coin, which is only an inch in diameter, will quite blot out the moon, which is 2,160 miles across, and this again blots out millions of miles of Space containing stars away in the distance beyond.



The size that a thing appears depends upon its distance from us. The Moon looks as big as the Sun in the sky, but that is only because it is so much nearer. A boy can hide the Moon by holding a halfpenny in front of his eye, and similarly the Moon can blot out an area of distant space hundreds of millions of square miles in extent

As we look up in the sky the Sun and Moon appear about the same size, but the diameter of the Sun is more than 400 times greater than that of the Moon. It appears small, however, because it is nearly 400 times more distant.

In the old days men had strange ideas about the Milky Way. The Oriental peoples regarded it as a silver river whose fish were frightened by the new moon which they imagined to be a hook. Our Norse forefathers knew it as the path to Valhalla, along which went the souls of heroes who fell in battle. As we know from Longfellow's "Hiawatha," the North American Indians believed it to be the broad white road along which the ghosts of the departed travelled in crowds to the land of the hereafter.

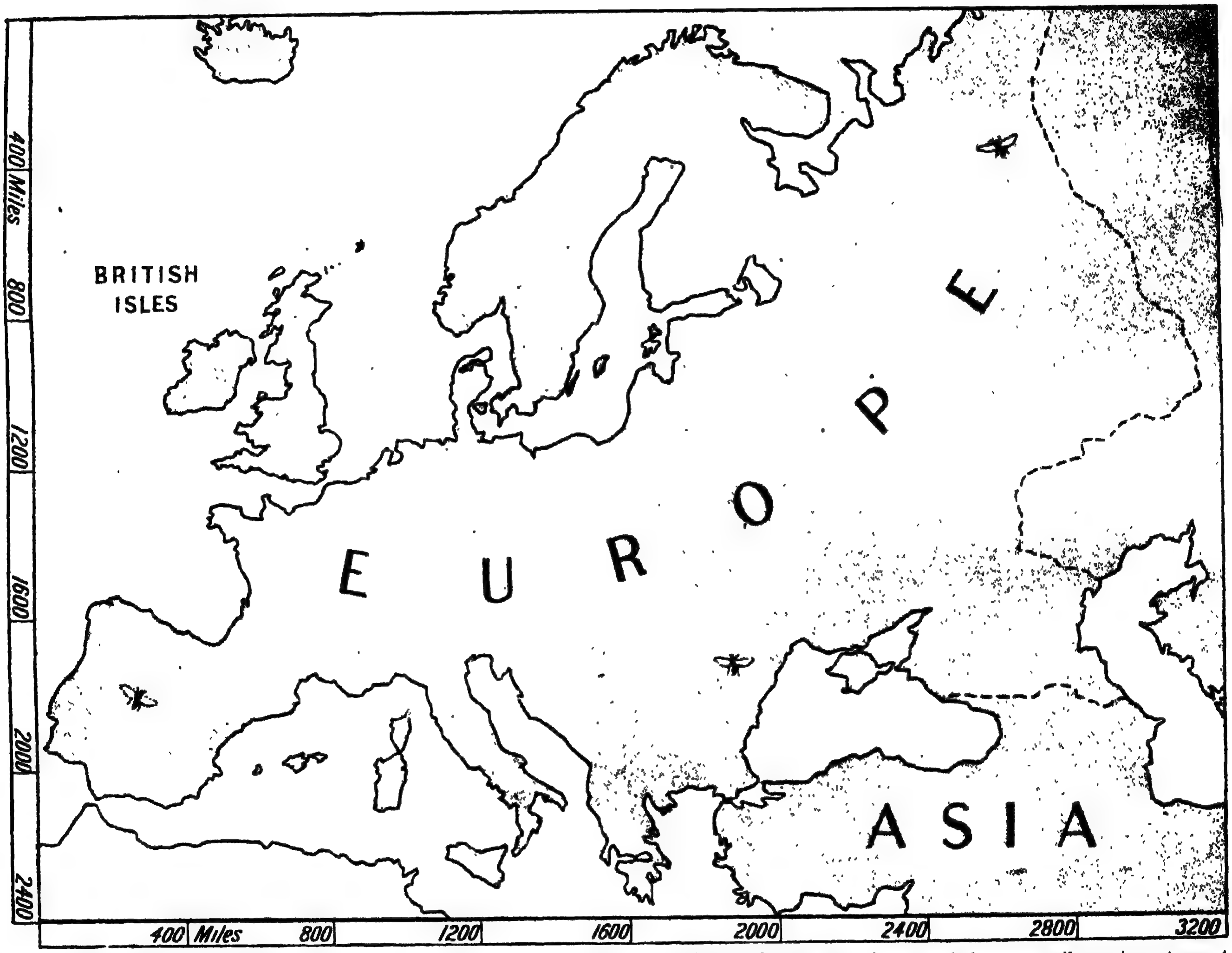
Its real nature was not known till the great Galileo turned his telescope upon the Milky Way and found that it was a cloud of faint stars like shining dust against the dark background of the sky. This idea of dust has run in the minds of the poets. Our own Milton says:

A broad and ample road whose dust is gold,
And pavement stars, as stars to thee appear
Seen in the galaxy, that milky way
Which nightly as a circling zone thou seest
Powdered with stars.

But while it was known that the Milky Way went right round the heavens like a ring, its true character was only first discerned, and then but dimly, by Sir William Herschel just over 120 years ago. He imagined the Galactic system to be like an enormous cartwheel, with the Sun at the hub and spokes of stars linking this up with the rim or band of the Milky Way. Scientists now believe that this great system is shaped rather like a lens than a wheel, but it is to Herschel that we owe the beginning of the idea of what the Milky Way really is. Astronomers have since discovered that the Sun is nowhere near the hub of the wheel; rather it is, as Sir James Jeans suggests, "part way along a spoke, perhaps something like a third of the way from hub to rim."

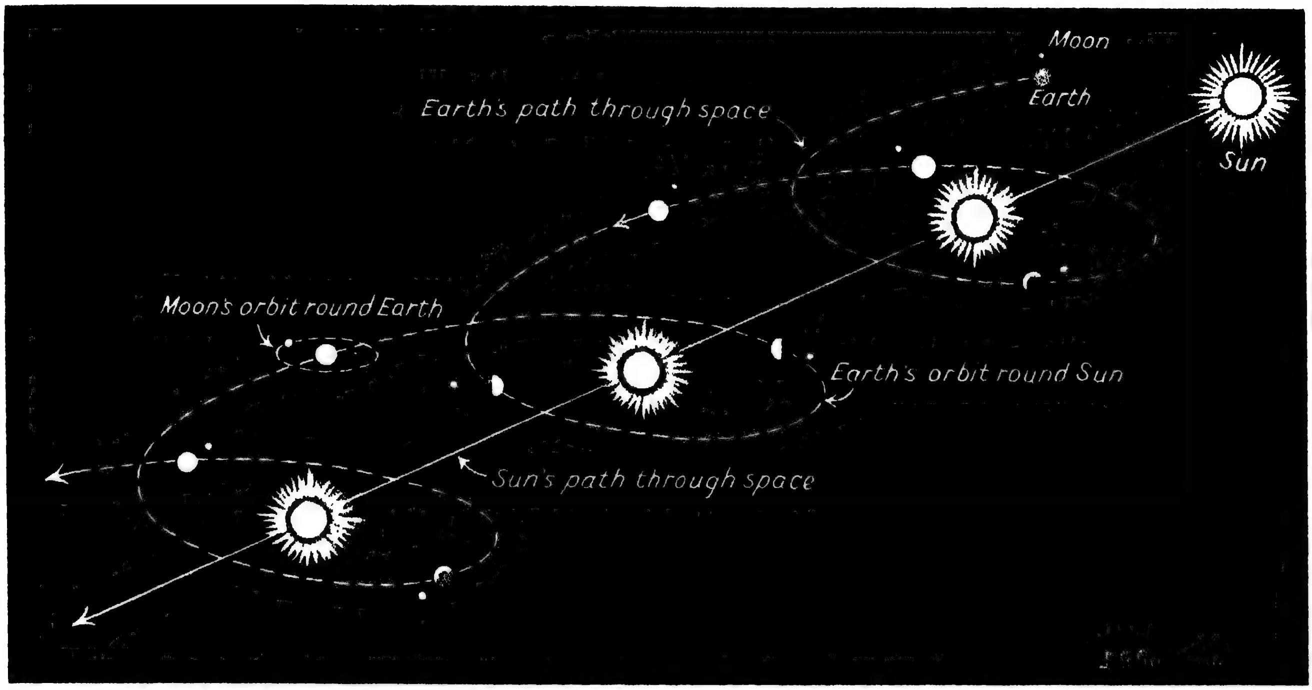
The wheel—that is, the Milky Way system—is rotating in space round a point about 50,000 light-years from our solar system. It is because of this rotation that the Galactic system is able to retain its shape of a lens or wheel. If it were not for the rotation, the outer stars would be drawn in towards the centre till they were united in a bunch. The stars of the Milky Way are clustered thickest near the centre or hub, where the telescope in conjunction with the camera shows a great cloud of stars in the region of the constellation Sagittarius, or the Archer.

It is well that we should realise something of the marvels of Space, and in other parts of this book we learn that men of science have in recent years discovered that the Space between the stars is not empty, as they thought, but filled with gas: and further, that this gas is not cold, but intensely hot.



Some astronomers believe that there are over 300,000 million stars in the Milky Way system alone, and these are all moving at great speeds. Why is it that they do not collide? Sir James Jeans says that space is so vast that it is emptier than anything we can imagine. If only three wasps were left alive in the whole of Europe, as shown here, the air of Europe would still be more crowded with wasps than space is with stars. We can understand how almost impossible it would be for three wasps flying about in Europe to meet

THE EARTH'S REAL PATH THROUGH SPACE



We always speak of the Earth's annual journey round the Sun as being in an almost circular path or an ellipse, that is, not quite a circle. Of course, in giving diagrams of the Earth's surface, the ellipse is greatly exaggerated. But the Earth's orbit is an ellipse only if we consider our planet's relation to the Sun itself. Actually the Sun is travelling through space at the rate of about eleven miles a second towards the bright star Vega in the direction of the constellation Hercules. The result is that if we could go away into space and watch the Earth in its journey round the Sun, the path would look very different from the ellipse which is usually drawn in our geography and astronomy books. This picture shows what the Earth's yearly passage really is like. Our planet goes round the Sun, it is true, if we consider only the Earth and Sun, but when we take into consideration the Sun's journey through space, then the Earth's path as viewed from a distance would appear as shown here, a series of loops

WHAT A MAN WOULD WEIGH ON DIFFERENT WORLDS

When we say a man weighs twelve stones, we mean that the pull of the Earth, or gravitation, as we call it, exerts a force of twelve stones upon the matter in his body; or, in other words, the attraction of the Earth pulls his body in the direction of its centre with a force equal to 168 pounds.

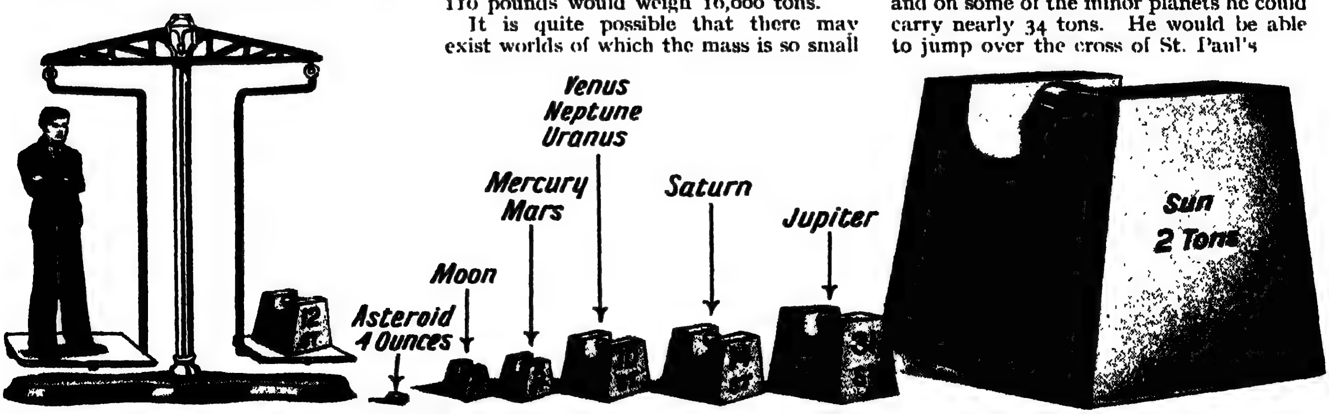
Now the pull of the Earth, or any other planet or heavenly body, depends upon its size and the amount of matter in it. The smaller and lighter the planet, the less its pull, and therefore the less a man would weigh on its surface.

For example, a twelve-stone man on the Moon would weigh only two stones, but on Jupiter he would weigh 31 stones, and if it were possible for him to exist on the Sun, he would there weigh two tons. On the other hand, if he could go to one of the small asteroids or, as they are more correctly called, minor planets, which circle round the Sun between Mars and Jupiter, the twelve-stone man would weigh only four ounces.

As already stated, it is not merely the size of the world that affects its pull on bodies at its surface; it is its density as well. Suppose the Earth, with its present size, had its matter so closely packed together that it were as heavy as the Sun is now; then a pound on the Earth's surface would weigh 324,000 pounds, and a young girl whose present weight is 110 pounds would weigh 16,000 tons.

It is quite possible that there may exist worlds of which the mass is so small and the motion of rotation so rapid that the centrifugal force would overcome the gravity, and bodies would weigh nothing at all. The intensity of gravity at the surface of the different planets varies very greatly. If we reckon the pull of the Earth as 1, then the Moon's gravity is only 0.16; that of Mars 0.38; that of Mercury 0.26; Venus 0.90; Uranus 0.96; Neptune 1.0; Saturn 1.13; Jupiter 2.64; and the Sun 28.0.

As already explained on page 15 of this book, the reduction in the pull of gravitation would mean that a man could do much more in the way of work or physical exertion. If on the Earth he could carry 1 cwt., on the Moon he could carry 6 cwts., and on some of the minor planets he could carry nearly 34 tons. He would be able to jump over the cross of St. Paul's



WHAT A 12-STONE MAN WOULD WEIGH ON DIFFERENT PLANETS AND ON THE SUN

HOW WE ALL DEPEND ON THE ASTRONOMER

Many people must have asked themselves "Of what use is astronomy? What good can it be to mankind to know the weight of Jupiter, for instance?" Yet the patient, never-ceasing work of the astronomer is of vital importance to us every day of our lives, did we but know it. In the following chapter we learn some remarkable facts about the astronomer and his wonderful work in the great observatories of the world, many of which are situated on high and lonely mountains.

It might be thought that astronomy, the study of the heavens, was not of much use to ordinary people. But, in fact, it is of very great importance, not merely to a few men of science but to all of us, in our daily lives. For instance, without astronomy it would be impossible for us to keep our clocks and watches accurate: nor would the sailor be able to guide his ship accurately from port to port. He would have to waste much time if his knowledge, acquired from the astronomer, of the Sun, the stars and the planets did not help him on his way, and waste of time would be waste of money, so that all the goods we buy from overseas would cost us more.

Astronomy also helps us with past time as well as with the present, for we can check a date in history by, say, the record of an eclipse.

Helium, which is one of the chemical elements, was detected in the sun by astronomical observation in 1898, but it was not found on our earth until 1895. Helium is an exceptionally buoyant and non-inflammable gas. If it had been used to inflate the British R101 and the German Hindenburg these huge airships would not have been destroyed by fire with heavy loss of life.

Good Work for Mankind

The astronomer, then, is a man who is doing much good work for mankind. He has to work very hard, and usually for a small reward. The work in a big observatory, such as that at Hurstmonceux or the Lick Observatory in California, is carefully divided up among the various members of the staff, just as it might be in a big factory. The astronomers work in shifts both day and night observing the universe of sun, planets and stars.

He lies down on a mattress beneath the eyepiece of a big telescope, which is kept fixed by a special motor on the particular star or planet under observation. But for the motor the earth as it rolled round on its axis, carrying the observatory with it, would soon move the telescope out of range of the object on which it was fixed.

The famous Lick Observatory on top of Mount Hamilton, California, where, with giant telescopes, astronomers have made many marvellous discoveries in the heavens

How the astronomer watches the stars and planets through the 28-inch telescope at the Royal Observatory

Very often the astronomer has to put up with considerable discomfort from stiffness and from cold, for the problem of heating an observatory is a very difficult one. This is because any current of warm air would cause the atmosphere round the lens to quiver, as we see it do on a hot day in the summer, and this would make accurate observation impossible.

It is interesting to recall that Caroline Herschel, sister of Sir William Herschel, the famous astronomer who did such wonderful pioneer work with the telescope, used to sit for long hours in the open air assisting her brother with his records till her fingers became numb with cold. Sometimes the very ink froze in the bottle she was holding in her hand.

The astronomer has to keep his attention fixed not only on the stars but also on a number of complicated instruments which record his observations and check the knowledge he has helped to accumulate. Tremendous mathematical calculations have also to be made, while there is always the danger lest a cloud obscure the sky and spoil the night's work.

Up in the Mountains

It is in order to take advantage of the purest atmosphere that so many observatories are built on high mountains. On these bleak heights the astronomer, far removed from the rest of the world, spends an arduous life matching his tiny brain against the enormous problems of the universe, so that man's knowledge and power may be increased.

So we see that the astronomer is not merely a man who pursues a rather expensive hobby. One of his greatest services to us all is the removal of the doubts and fears which formerly troubled mankind. At one time an eclipse was thought a terrible thing, perhaps foretelling the end of the world, while comets were supposed to bring plagues and other disasters in their wake. Now, thanks to the astronomer, we know better.

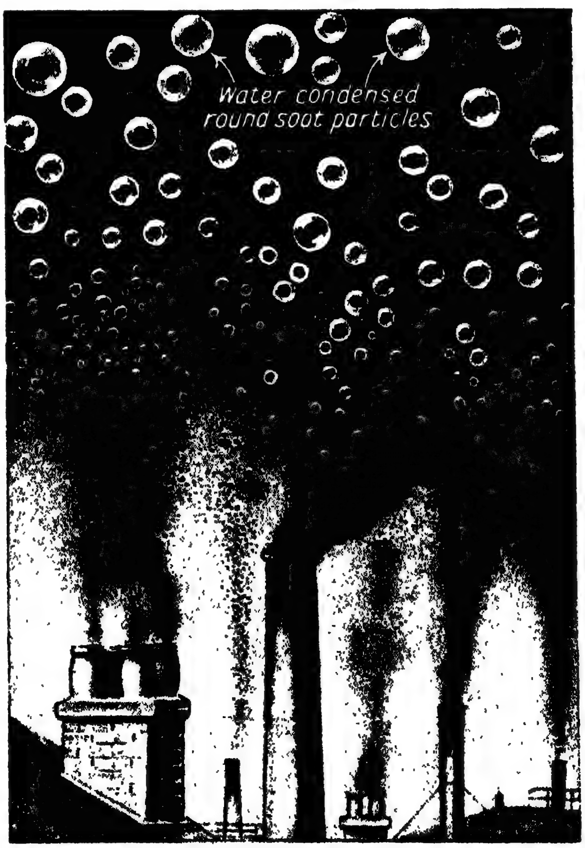
FOGS AND HOW THEY ARE CAUSED

Water vapour, which is constantly arising from the land and sea, is quite invisible. But when it reaches a colder layer of air above the ground it becomes condensed into minute drops of water, each forming round a particle of dust. These drops collected together form clouds when they appear above our heads, but when the water vapour condenses at or near the ground we call the result fog. In these pages we read some interesting facts about fog and its formation and the great damage it does in cities and towns

FOGS, which in a climate like that of England occur more or less every winter, not only cause an immense amount of loss, but are also a menace to life and limb.

Of course fogs, which are only mists containing larger particles of water, have played a considerable part in history. By coming down suddenly on a battlefield they have enabled an army to retreat or to attack unexpectedly. Thus it was a fog that helped George Washington to retreat to New York after the battle of Long Island, in which he was defeated. Occurring on the sea, fogs have led to attack or escape of whole fleets.

Their most important interference with human life, however, is in connection with industry and commerce. A dense fog suddenly occurs in London or Manchester or Birmingham, and all traffic is suspended. Trains and tramcars and buses and motor-cars cease to run. People are late in getting to their work. Ships are held up in the docks. Goods cannot reach the warehouses and shops, and hundreds of thousands of pounds are lost as a result.



How a city fog is formed by a partnership between the soot from the chimneys and the water vapour in the air

Millions Lost by Fog

A dense fog in London which lasted a week during the month of December in 1905 is estimated to have cost the city £350,000 a day through suspension of business.

Tradesmen and shopkeepers lose thousands of pounds through damage to their goods by the fog, and the London Chamber of Commerce has estimated that the total losses through traffic delays, expenses in gas and electric light, hindrance to shipping and railway difficulties, caused by a fog in London amount to at least £1,000,000 a day.

Whenever there is a day or two of fog in England the number of deaths recorded goes up about a sixth, and the amount of illness caused is enormous.

If only fogs could be abolished the gain in life and wealth would be incredible.

Is there any possibility of doing away with fogs? Unfortunately there is not, but we could greatly reduce their frequency, their widespread area and their density.

Let us see what causes a fog. Warm air passing over the sea takes up a certain amount of moisture, and as long as the air keeps warm this moisture is in the form of invisible vapour, but if the stream of air happens to meet a colder layer or passes over cool ground or becomes cool in some other way, some of the aqueous vapour in the air immediately condenses into minute drops.

However, before moisture can condense into tiny drops of water it must have a solid substance on which to condense. Obviously, then, where there are more solid particles in the air, such as are provided by soot from chimneys, there the fog is more likely to occur. That is why cities like London and the manufacturing towns of the north of England are so much more subject to fogs than the small towns and country districts.

No fog could occur in an atmosphere that was entirely free from solid particles and, of course, no fog can occur in windy weather, for the moisture is blown away as fast as the aqueous vapour condenses.

Clouds are really clean fogs in the upper atmosphere, and if an airman flies over London or some other city when it is enveloped in fog, he sees, as he looks down, what appears to be a great bank of clouds, the same kind of thing that we see from the ground when we look up on a cloudy day.

The density of a fog depends upon the number of water droplets in every cubic inch of air. Of course, the droplets vary in size, but they are often only about one 3,000th of an inch in diameter, that is, it would take 3,000 of them placed side by side to measure an inch. When there are only a thousand droplets in a cubic inch of air the fog is very light indeed, and a heavy fog has something like 20,000 droplets to the cubic inch. Often the number is far greater, and in some very dense fogs nearly a million droplets are found in the cubic inch of air.

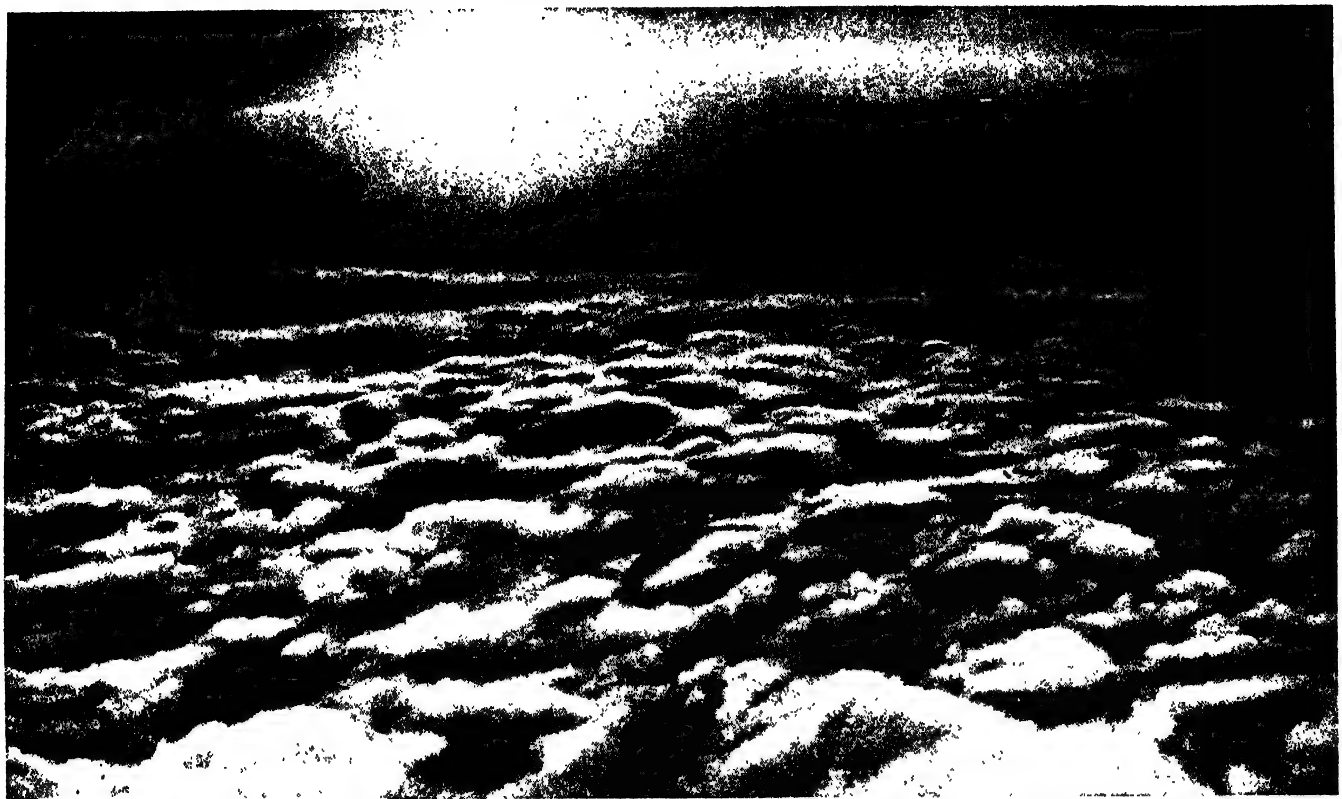
A Bath of Fog

When there are 20,000 droplets to the cubic inch, it is impossible to see beyond a hundred feet. Scientists tell us that a block of fog three feet wide, six feet high, and a hundred feet long, contains less than one-seventh of a glass of liquid water, so that if a bath full of water were expanded into fog droplets, the whole of London would be completely enveloped.

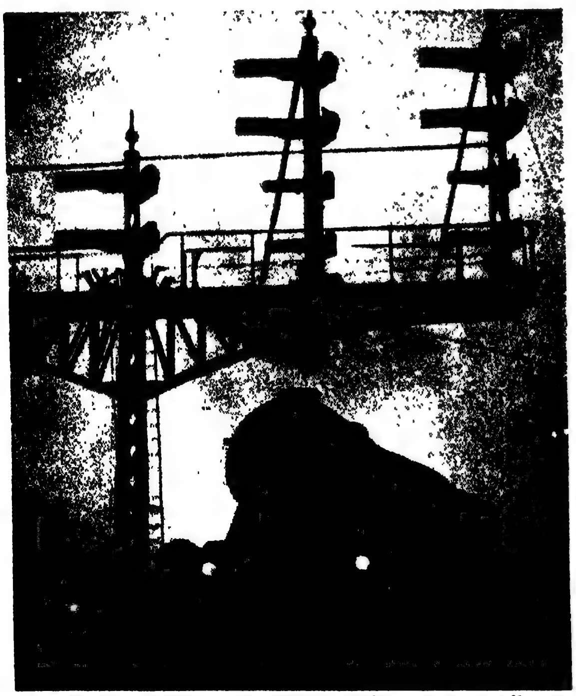
There is a great difference between the appearance of a fog in the country and a fog in a great city like London or Manchester. The dark fogs of our cities and manufacturing towns are caused by the large amount of solid matter mixed up with the droplets of water, this matter consisting of particles of soot thrown out by chimneys.

The amount of soot from chimneys

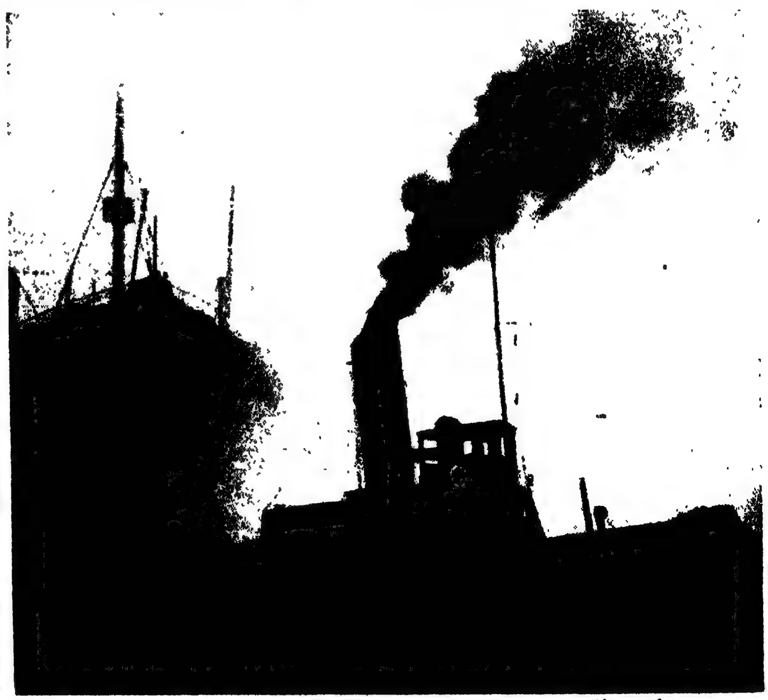
ABOVE AND BELOW IN A GREAT FOG



A fog is really a great bank of cloud, and when seen from above looks exactly like a cloudy sky seen from below. In this picture taken from the air we are looking down on a London fog from a height of nearly a mile above the streets. The photograph was taken by an airman. The fog is really made up of myriads of globules of water which have condensed from a moist atmosphere round tiny particles of dust, most of which are thrown up from chimneys where open coal-fires are burning. Without the dust we could not have fog at all. When there is a very great amount of soot in the atmosphere, as over industrial towns, the fog becomes dark and shuts out the Sun's light



Fog is one of the greatest problems that railway authorities have to contend with. It adds to the risk of travel and costs railways an enormous amount, for when signals cannot be seen explosive fog signals and expensive automatic-control systems have to be used. This picture shows an express train emerging out of a fog at King's Cross station, London



The risks of travel in fog are even greater on the water than they are on the railway, for while the metals keep the trains on given tracks, there are no definite tracks for ships. Fog-horns have to be constantly sounded, and even then collisions are likely to occur, though that risk has been greatly reduced by the invention of radar. Ships in ports like London or Liverpool are often held up for hours, and sometimes for days, by thick fog. Here a large steamship is being towed through a fog over the Thames

that falls upon great cities is almost unbelievable. Over the entire area of London in the course of a single year the soot fall is about 46,500 tons. In Birmingham the annual soot deposit is 440 tons to the square mile, in Manchester 425 tons, in Blackburn 640 tons, in Liverpool 660 tons, in Rochdale 793 tons to the square mile, and in Newcastle-on-Tyne, the worst sufferer in England, about a thousand tons of soot descend from the atmosphere on every square mile in the course of a year.

These figures are obtained by men of science who work patiently collecting and examining samples of the atmosphere hour after hour. Self-recording instruments are fitted with tapes of clean paper, on which every particle is preserved. Then the record is magnified, the particles counted and analysed, and finally a calculation made, which gives the record for a whole district or city.

According to Dr. John S. Owens, who has made a special study of the subject, the average individual walking in London during a black fog breathes in about 14,000 million soot particles per hour.

In Manchester things are rather worse, for a man walking in that city in a fog would breathe in 20,000 million particles in an hour. "If," says Dr. Owens, "you took the number of particles breathed in by one man in Manchester during ten hours of a smoke fog, and placed them in a single line one tenth of an inch apart, the line would reach from the Earth to the Moon."

It is not only the cities and towns themselves that suffer owing to the

An apparatus which records the amount of impurity in foggy air

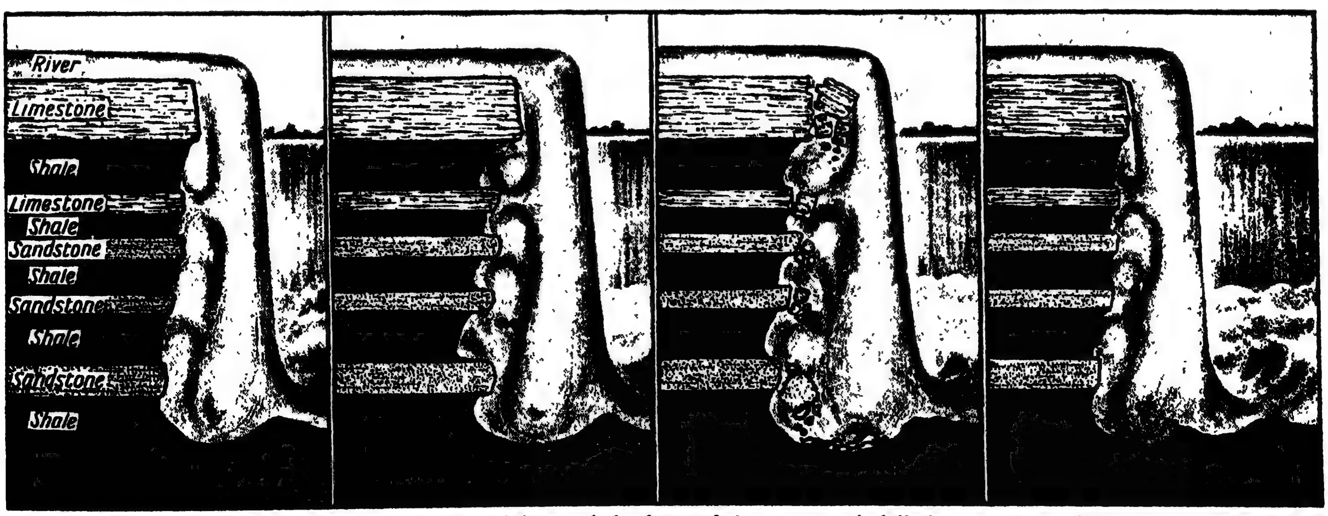
pouring out of so much soot from their chimneys, but large areas of the surrounding country. Professor Cohen, of Leeds, declares that smoke from an industrial town will easily travel fifty miles or more, the particles settling at a very slow rate. A particle shot from the top of a chimney a hundred feet high would take nearly three weeks to settle. No wonder, then, that flowers and crops do not thrive in the neighbourhood of industrial centres, and that health is less good in the town than in the country.

Not only in foggy weather does the pall of smoke deprive the people of cities and towns of health and sunshine, but even in clear weather the rays are shut out. Tests have shown that Manchester on a sunny day, receives only 70 per cent of the sunlight received in a village five miles away. Kew, seven miles west of the City of London, loses 37 per cent of the sunshine it should have owing to the London smoke. Many industrial centres lose 50 per cent of the sunshine they could have. Careful calculations made in Manchester have shown that owing to the smoke nuisance £50,000 a year is spent in the extra washing of collars.

No doubt one day this problem of the output of smoke will be properly tackled and dealt with, and then we shall have fewer fogs, more sunshine, and better health.

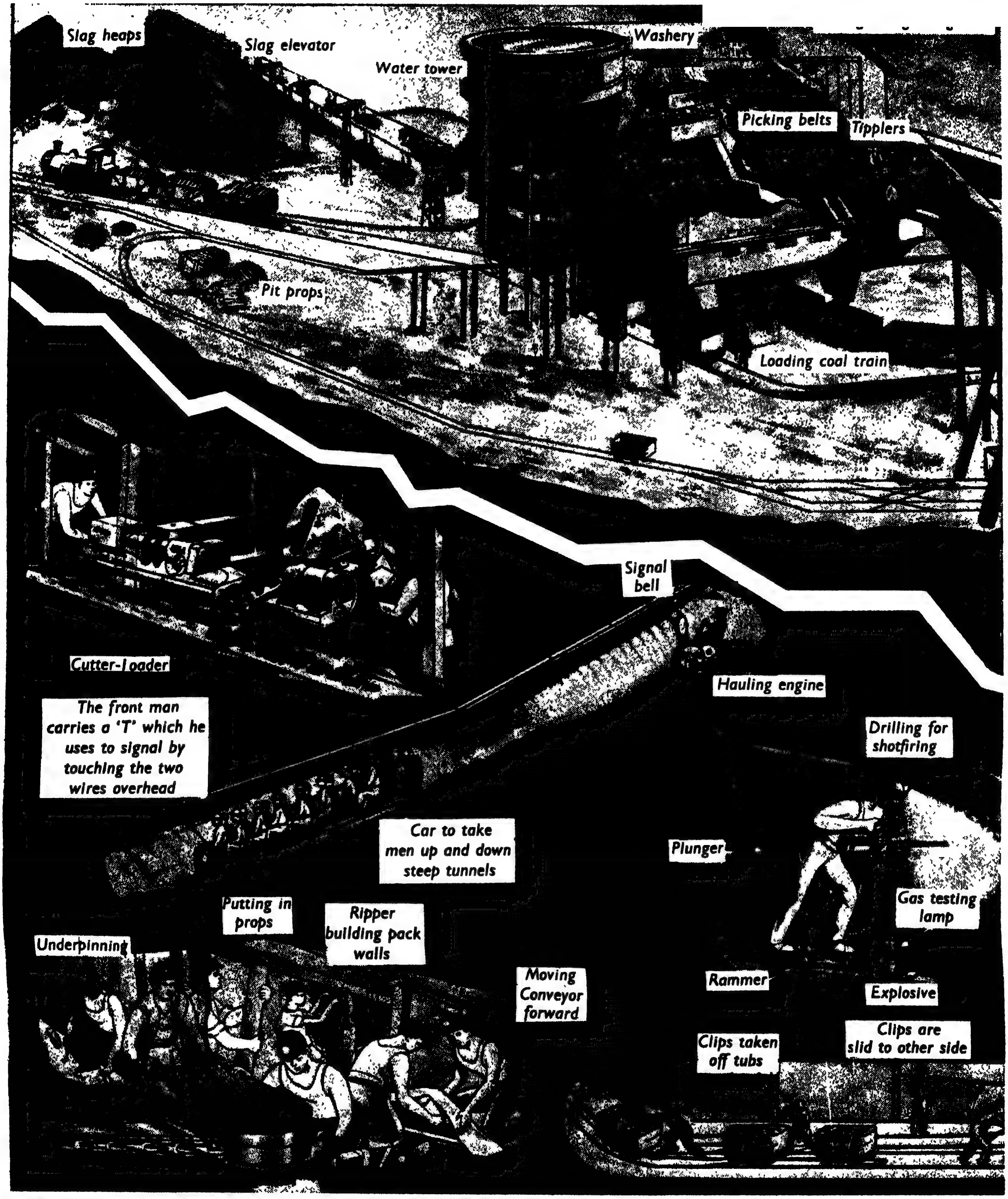
Fogs, of course, can never be abolished altogether, for wherever there is dust and moisture-laden air that is being cooled, there mist or fog will be formed, and microscopic dust, sufficient for the formation of fog, is found in all parts of the Earth's atmosphere. Even far out on the ocean, hundreds of miles from land, and on the tops of the highest mountains, water vapour always finds sufficient dust on which to condense. Fogs due to dust, however, are very different from fogs due to soot.

HOW NIAGARA IS WEARING AWAY THE ROCK



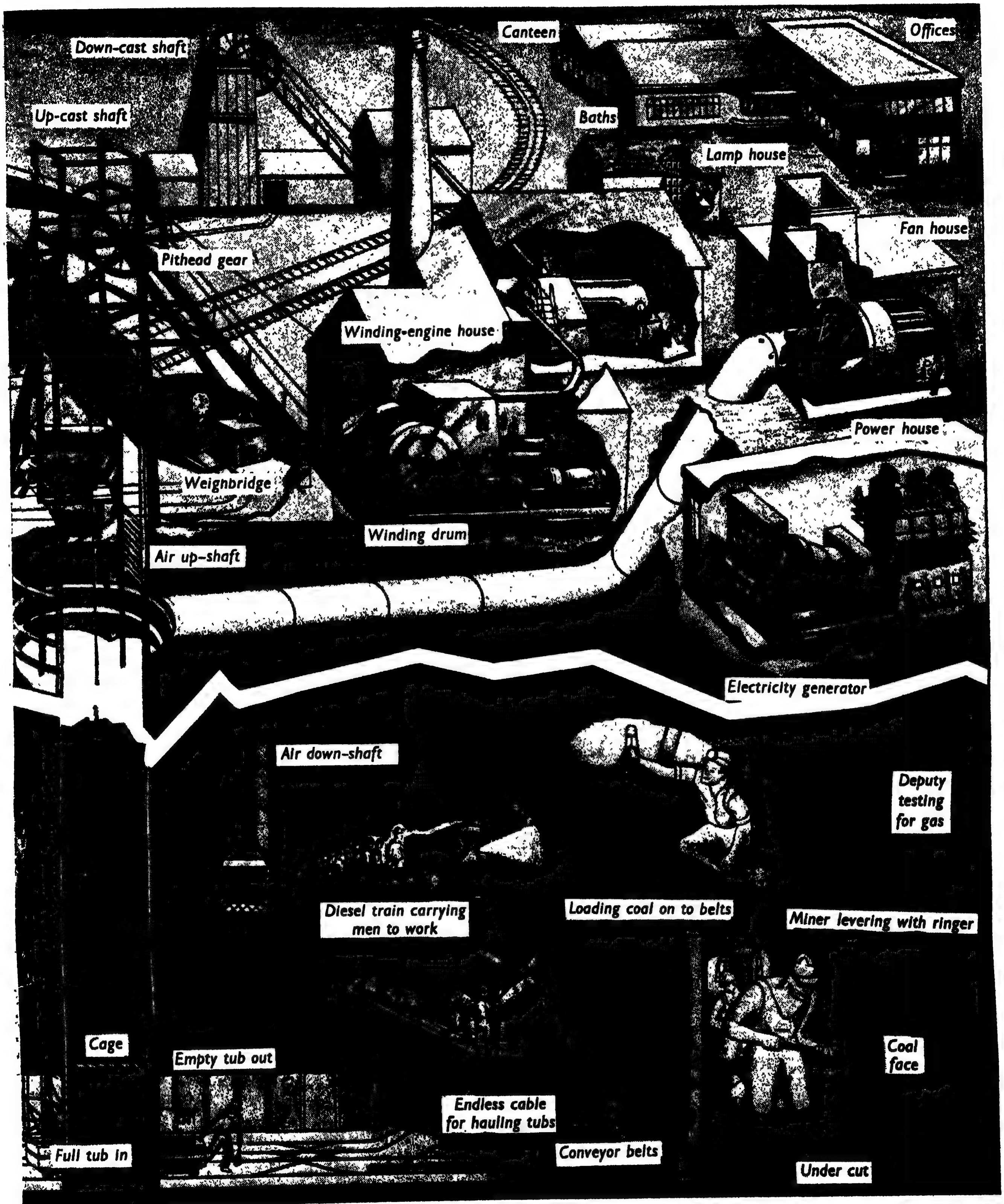
At Niagara Falls we see a river crashing over a precipice, and the force of the water as it falls is enormous. All the time it is wearing away rock, and during the last 100 years the Horseshoe Falls on the Canadian side have worn back the precipice about 370 feet. It is reckoned by geologists that the Falls have been about 30,000 years in the making, and every year they move farther and farther back. These four pictures show exactly how this wearing away is done. The water as it whirls down eats away the soft shale layers more rapidly than the harder limestone strata, as shown in the second picture. At last, when a good deal of the shale has been eaten into, the pressure of the water on the limestone breaks it away, as seen in the third picture, and then the whole business goes on again. The lower part of the precipice is always more eaten into than the top, because of the whirling of the water as it strikes the bottom.

MACHINES THAT DIG FROM COAL-MINES ENERGY



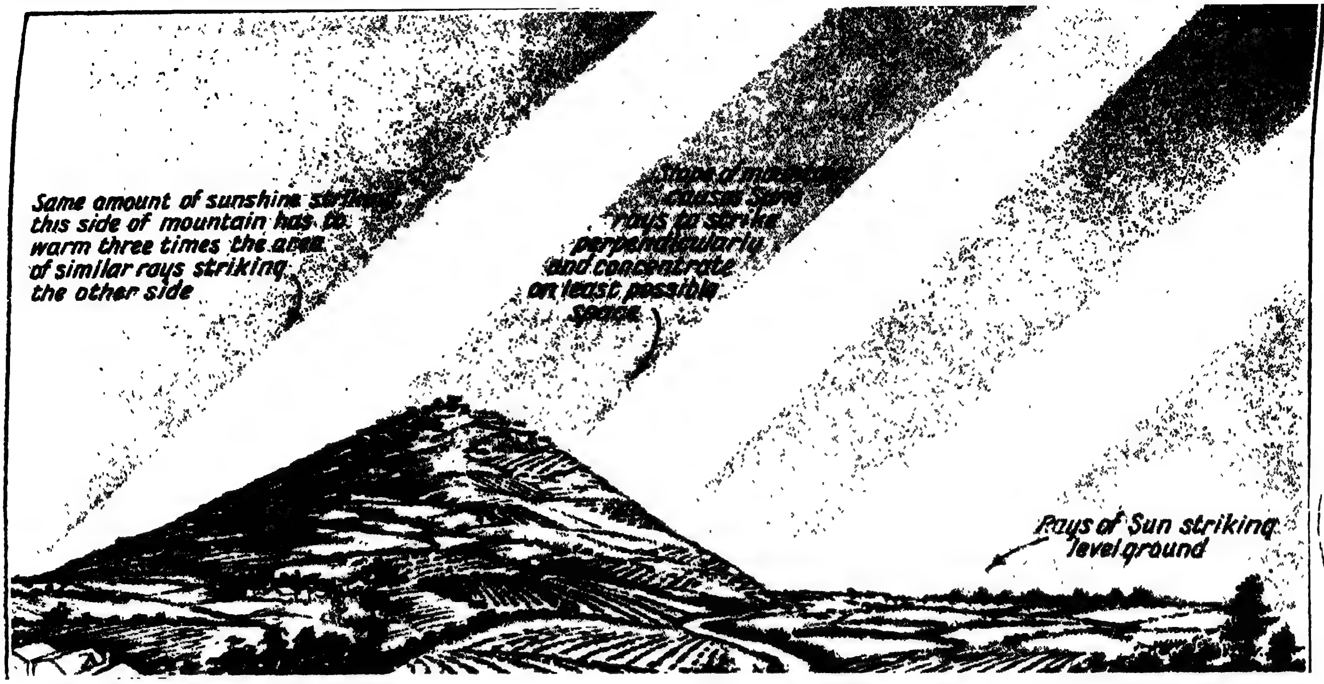
It is odd to think of sunshine coming from black stone dug deep from under the ground ; but the heat from burning coal is energy collected from the sun by trees and plants that grew millions of years ago. Chemical reaction with the sun's rays caused the plants and trees to absorb carbon, hydrogen, and oxygen, and these elements were imprisoned in the plants when they became covered with successive strata of clay, earth, and rock as the surface of the world changed throughout countless ages. Coal was at first used chiefly for burning as domestic fuel or for raising steam in engines. Today oil and atomic energy rival coal as a source of power, but the world still uses millions of tons every year not only as a source of power but for the extraction of gas and chemicals. This drawing shows the scores of ingenious machines and techniques now used to bring coal to the surface of the ground where the burning of its carbon,

CREATED BY THE SUN MILLIONS OF YEARS AGO



hydrogen, and oxygen content releases its heat energy. The mine shown above has two shafts, one called the down-cast shaft and the other the up-cast shaft. Fans draw air into the down-cast shaft from whence it circulates throughout the workings and is then extracted through the up-cast shafts. The shafts are also used as lift wells for taking the men to and from the workings and for bringing coal to the surface. The coal is dug out by mechanical cutters and loaded on to conveyor belts which carry it to trains or trucks drawn by diesel locomotives. Seams of coal are broken up by explosives into manageable lumps. As the coal is removed from the seams heavy cross timbers supported by wooden or steel props are put in position to prevent the roof from falling down. When the trucks come out of the mine the coal is washed in running water and is then thrown on mesh screens to sort the lumps into sizes

WHY A SUNNY SLOPE IS BETTER THAN A LEVEL FIELD



A sloping field that faces the south is more fertile than a horizontal field, while the side of a hill whose slope faces the north is much less fertile. The reason is shown in this picture. The Sun strikes all three from a certain direction, but the same amount of sunshine is concentrated into a much smaller space on the slope that faces south than it is on the horizontal field, while on the slope facing north the same amount of sunshine is spread over a much wider area and therefore provides less heat. All fertility comes from the Sun, so the land that gets most sunshine to the square yard, provided there is plenty of water, produces most life

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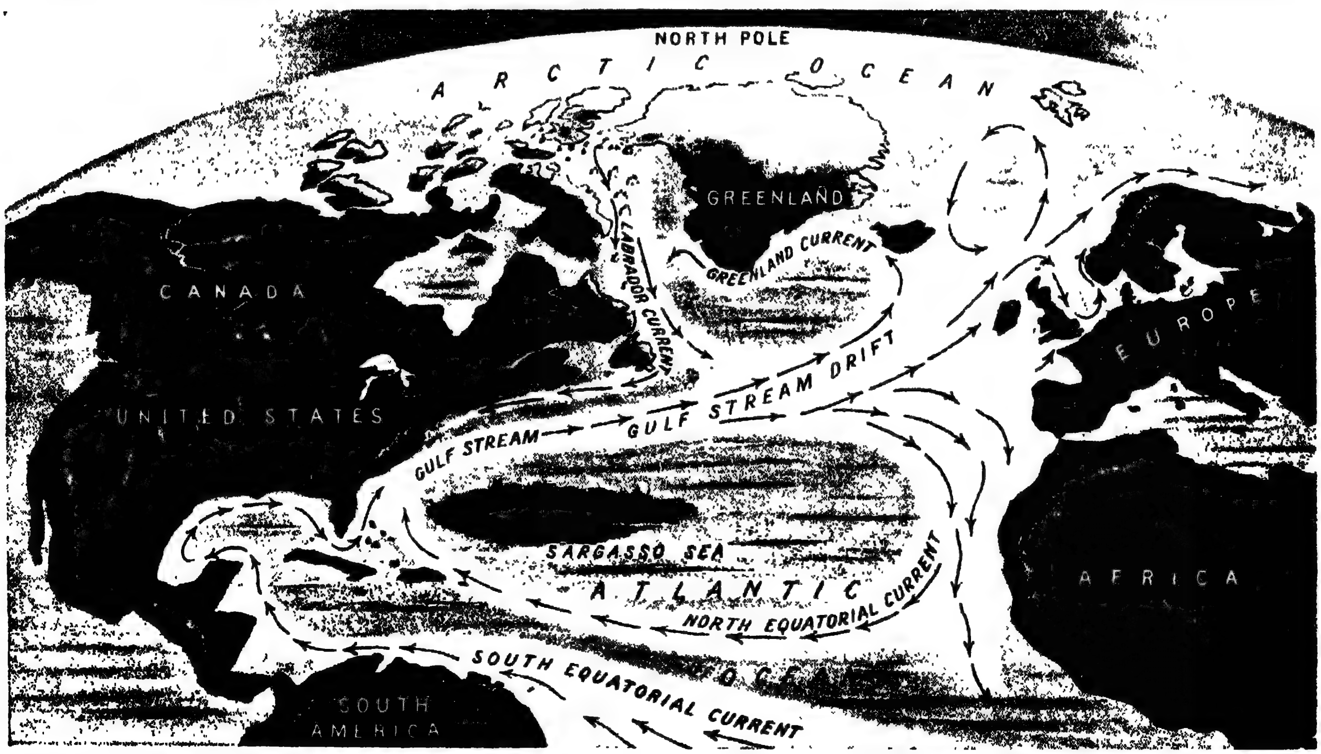
THE ATLANTIC'S GREAT FLOATING ISLAND OF SEAWEED



In the North Atlantic Ocean, lying some distance off the American coast, is a great floating mass of brown seaweed. It is called the Sargasso Sea, from the Portuguese word for seaweed, sargaco, and in it live myriads of small, marine animals. It was first seen by Columbus, and for centuries it was believed that any ship which got caught in the Sargasso Sea would be held prisoner for ever. The Michael Sars Expedition of 1910, however, showed that ships can pass through it safely. The accumulation of seaweed is due to the fact that this part of the ocean is calm, while round it circle currents, and the seaweed inside is thus herded together

THE WONDER OF A MODERN LIGHTHOUSE

Without the lighthouses round our coasts navigation would be a perilous undertaking. There are rocks and shoals in many places, and these must be marked if ships are not to go ashore and be lost. There have been lighthouses of a kind for thousands of years, but it is in recent times that they have become marvels of mechanism and illumination, and here we read something of their wonders

Lighthouses of some kind have been known from very ancient times. One of the seven wonders of the world was the great Pharos, or lighthouse, of Alexandria, but some hundreds of years before that was set up beacon fires had been maintained by priests on the Egyptian coast as warnings and guides to mariners in the Mediterranean. When the Romans came to Britain they built a pharos, or lighthouse, at Dover, and several beacons were maintained during the following centuries.

By the reign of Henry the Eighth, when British shipping and commerce began to grow, it became necessary to take the matter of lighthouses seriously in hand, and the King granted a charter to a society which was to build and maintain light beacons at certain points on the coast

The Early Lighthouses

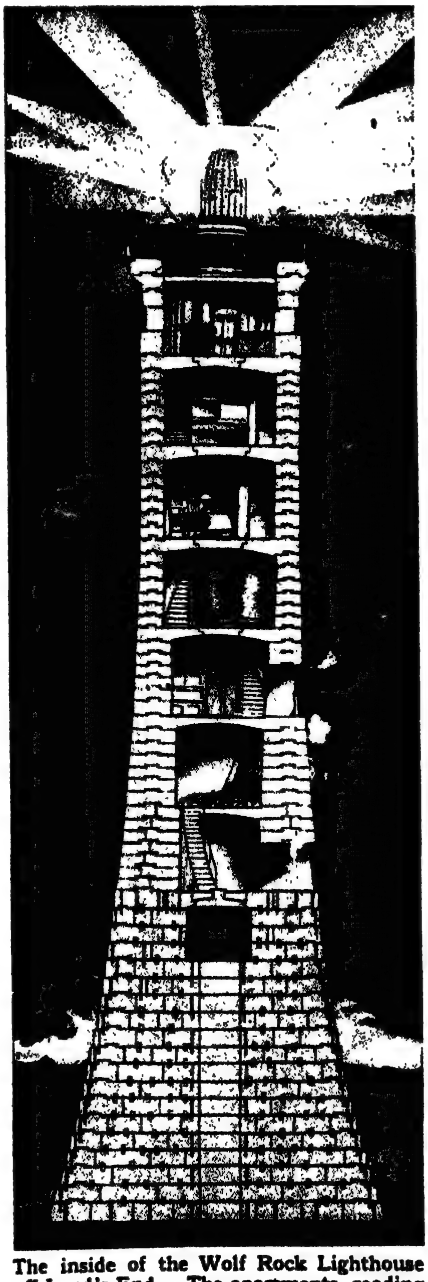
In the following century a number of other towers were set up round the English coast as lighthouses, but the light consisted merely of huge fires of wood and coal kindled on top. It must have taken a great deal of watchfulness and labour to keep up such beacons.

Later, candles were used, and then came oil lamps. The number of lighthouses, too, increased, and at last the Eddystone Lighthouse was built by Winstanley on a lonely rock off the south coast. It was a weird wooden structure, more like a pleasure pagoda in the grounds of an exhibition than a lighthouse to withstand the storms of the Atlantic, and one night during a great gale it was carried away, its designer being inside at the time

Strong as a Rock

A wiser system of construction for the lighthouse towers came into favour when Smeaton built the second Eddystone Lighthouse. It was made of massive blocks of stone, dovetailed together, the foundations being dovetailed into the solid rock itself, so that the lighthouse really became a continuation of the rock on which it was built.

Also the shape of the tower, tapering towards the top, was based on the principle of the tree trunk, which weathers the storms so well. There are, of course, different plans and designs for dovetailing the stonework, but the principle of Smeaton is still used. The walls are made much thicker at the bottom of the lighthouse than at the top, and in the Wolf Rock Lighthouse, for instance, off Land's End, which is shown here, the walls at the level of the entrance door are nearly eight feet thick, and they gradually decrease till they are only two and a quarter feet near the top



The inside of the Wolf Rock Lighthouse off Land's End. The apartments, reading up, are water tank, entrance hall, coal cellar, store room, oil room, living room, bedroom, service room and lantern

It is in the brilliance of the light that the most marvellous improvements have taken place in recent years. Oil, gas and electricity are all used, but the power of the light is enormously increased by the wonderful system of lenses through which the light is made to shine.

Not only is the light magnified, but all the rays, including those which would be lost above and below, are caught and bent so as to shine out in parallel beams. In this way exceedingly brilliant beams which shine across the seas for many miles are obtained. In lighthouses which are to shine only in one direction a combination of lenses, prisms and reflecting mirrors gives a concentrated and powerful beam. There are all sorts of combinations of lenses and prisms, but the principle is more or less the same and can be seen in the picture on page 52.

The First Revolving Light

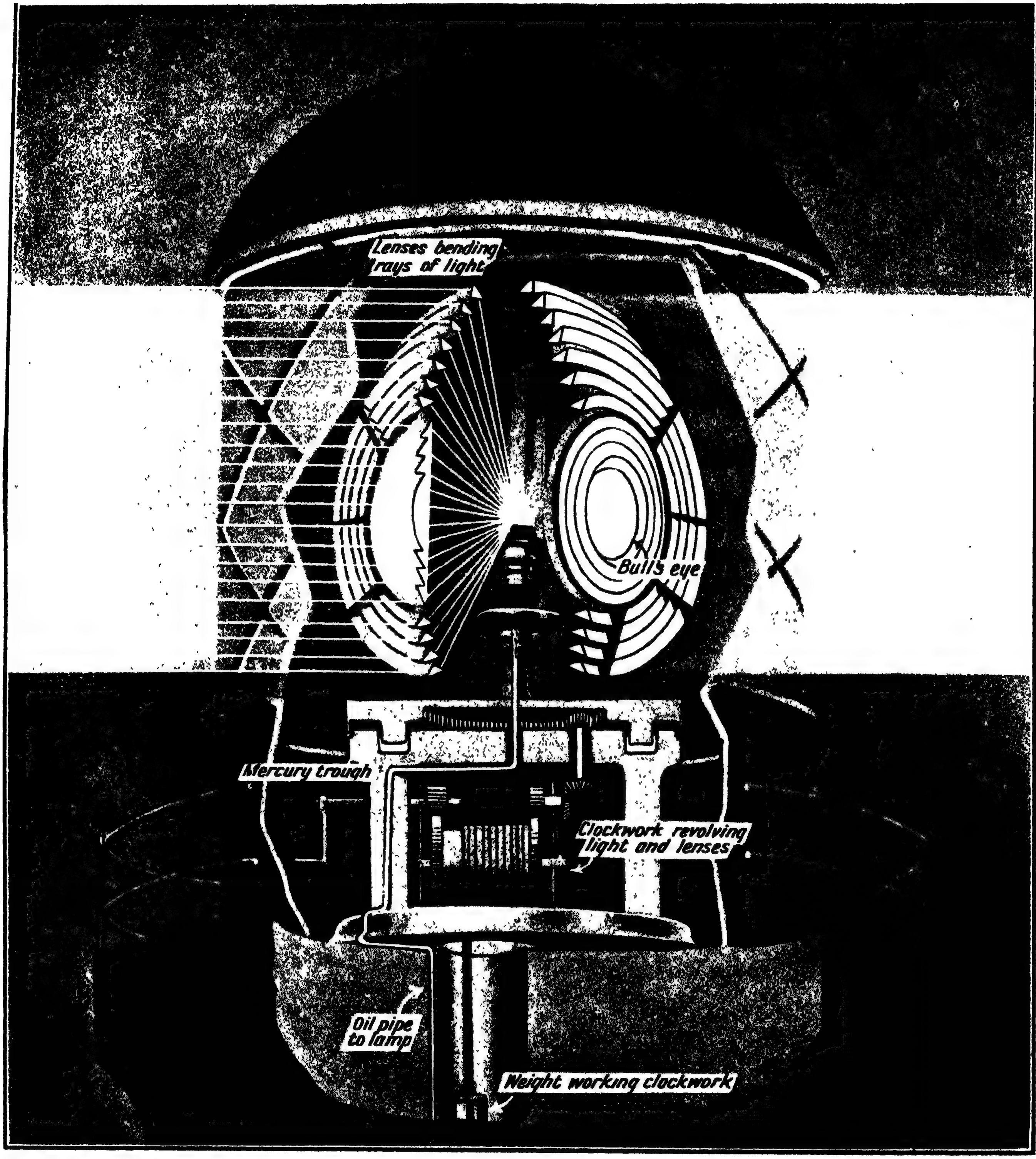
In order that the mariner on dark nights may distinguish one lighthouse from another, and not mistake his position, various systems of revolving and flashing lights are arranged. It was in 1783 that the first revolving light was erected at Marstrand in Sweden, and at the beginning of the 19th century one was placed at Flamborough Head. Now there are many revolving lighthouses in different parts of the world.

Up to Smeaton's day coal and wood fires had been used to give the light, but he, for the first time, used tallow candles, placing 24 in a chandelier, and the total value of the light was only 67·2 candle power. Contrast this with the present illumination of some lighthouses, which throw a beam of over 60 million candle power that can been seen for a distance of more than 30 miles.

Lighthouses on Sand

Most lighthouses to-day are triumphs of engineering. Their strength and the skill with which they are built on foundations of all kinds would have astonished our forefathers. It is difficult enough to build a lighthouse on a lonely and storm-beaten rock far from land, but it is no less wonderful to erect one that shall stand firm on a foundation of sand. Yet many such exist.

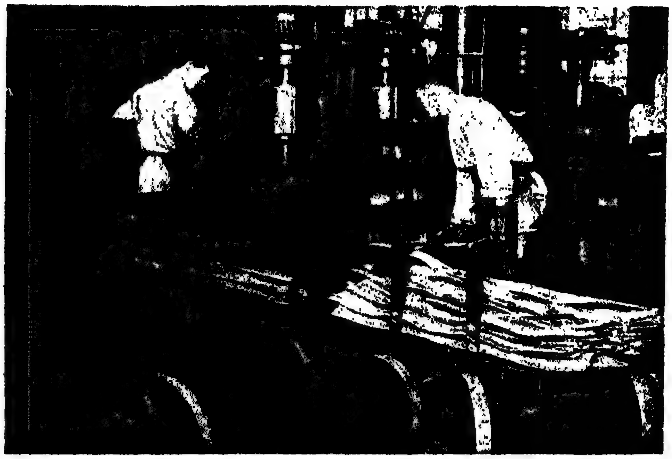
INSIDE THE LANTERN OF A LIGHTHOUSE



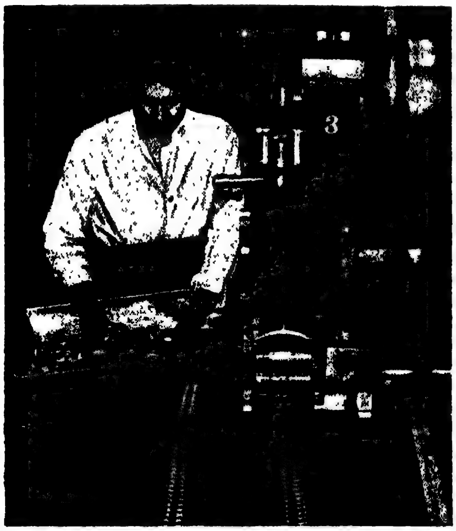
The lantern of a modern lighthouse is a marvel of inventive ingenuity. The light may be provided by oil, gas or electricity, and if it is oil this is pumped up by machinery. Then the light is enormously increased by a system of lenses, prisms and reflectors, so that little or nothing of it is lost. Those rays which might pass away above or below are caught by the lenses or prisms, and are bent so that the whole light shines as one beam. In many cases the light revolves so that the beam shines out in different directions in turn, or a shutter is brought in front of the light at regular intervals. This gives a unique character to each lighthouse, so that a mariner on the look-out is able to know which lighthouse it is whose beams he sees. Nothing is left to chance nowadays, for everything works automatically, and the turning of the light or its blotting out for brief regular periods is brought about by clockwork mechanism. The clocks, worked by weights or springs, in many cases give a warning when they need to be rewound. The lamp turns in a mercury trough, so that there may be as little friction as possible. Of course, the outside glass of the lantern has to be very thick to withstand the storms. Usually, plate glass a quarter of an inch thick is used, and sometimes in places of great exposure the glass has to be an inch thick. A wire grille is fitted outside the lantern to prevent sea birds attracted by the light flying against the glass and breaking it. The lanterns vary greatly in diameter, some being as much as 16 feet. Of course, lighthouses have to be fitted with a lightning conductor

MAKING MILLIONS OF MONEY AT THE MINT

The first step in making money at the Royal Mint is to melt down and mix in furnaces the various metals, as is being done here. A crucible of molten metal is being stirred by the workman



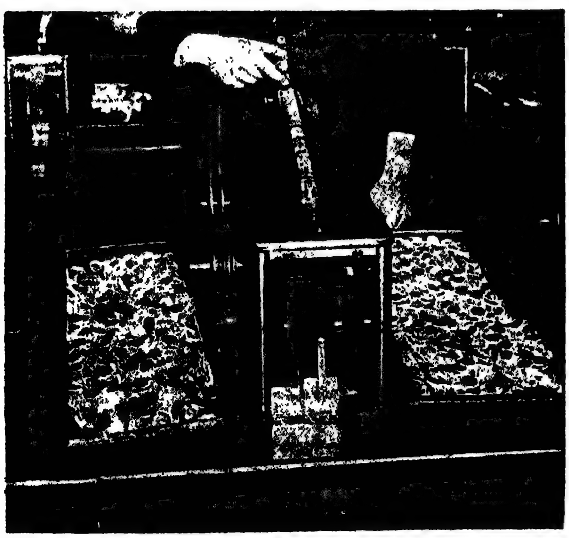
After the metal is cooled it is rolled up and cut into strips ready for stamping. Here we see the strips of silver passing through a revolving press which rolls them to the right thickness while cold



The band of metal is then passed through a machine which stamps out the discs ready for the impression of the Queen's head

The discs are next examined over a tray perforated with holes, which allows discs which are too small to pass through

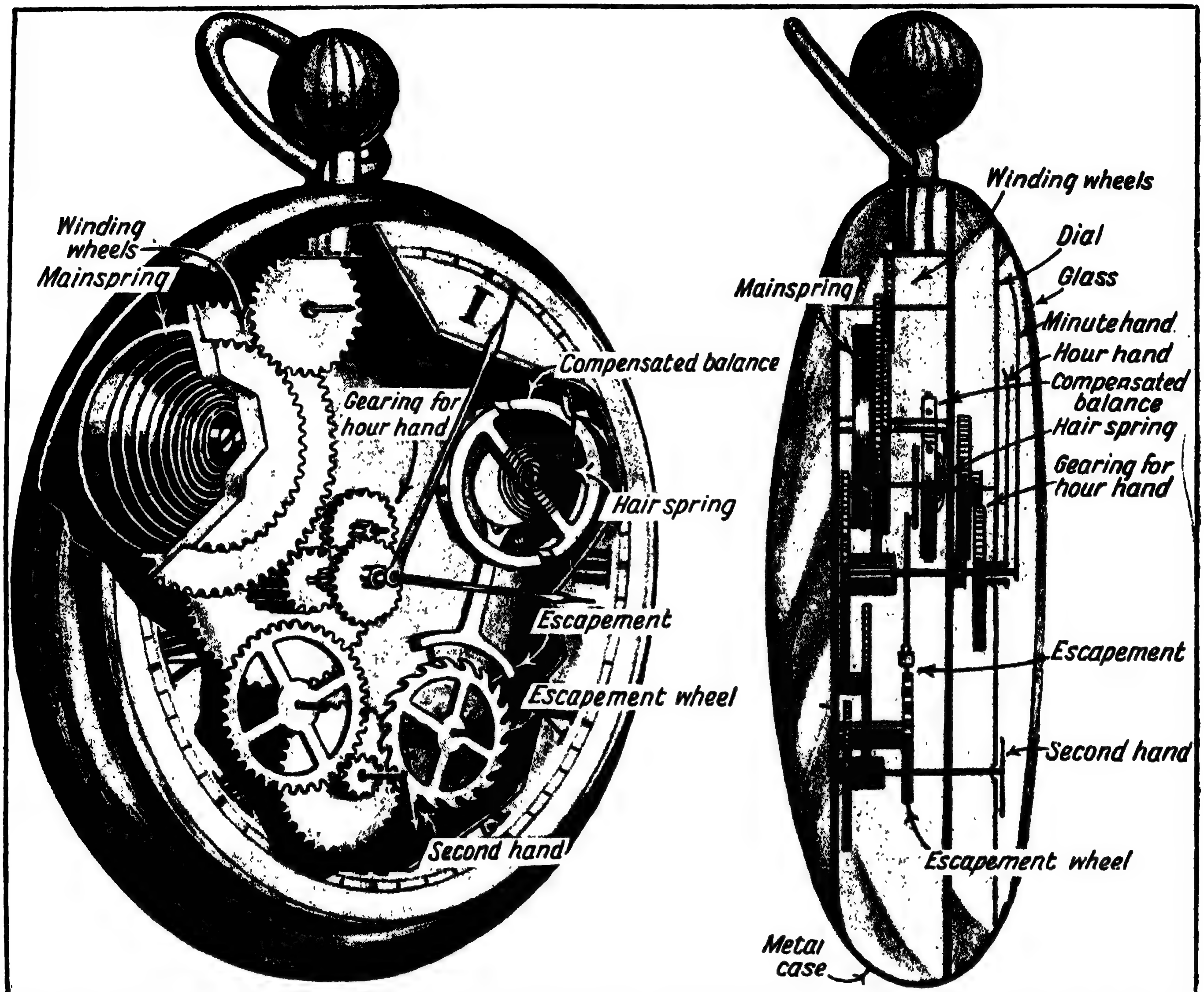
The discs are then placed in this machine, where they slide down between dies which stamp upon them their "heads" and "tails"



When the coins are completed they are passed through this automatic weighing machine, which sorts them into light, medium, and heavy weight coins

Finally, the perfect coins are put into bags, weighed automatically, and then packed on to trolleys ready for delivery to the banks, which put them into general circulation so that we may get them for use

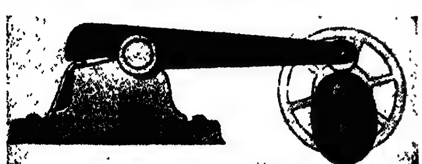
HOW A WATCH TELLS THE RIGHT TIME



These pictures, enlarged for the sake of clearness, show how a watch works. When we turn the key at the top we wind up the mainspring tightly At once it tries to unwind, and in doing so turns a train of gear wheels by moving one to which its end is fastened. An ingenious device known as the escapement prevents the spring running down in a moment or two, whirling the wheels round too quickly The escapement has a curved cross-bar with two little projections known as pallets. It swings backwards and forwards, and only one of the pallets at a time can rest on the teeth of the escapement wheel. As this wheel turns slightly, a pallet catches one of the teeth and holds it for a moment, but as the escapement swung forward it turned a little wheel at the top known as the compensated balance, which partly wound up a tiny hair spring Immediately the escapement has completed its swing, the hair spring begins to unwind, turns the wheel, and swings the escapement in the other direction. That releases one tooth of the escapement wheel, and thereupon the escapement swings back. As it does so it winds up the hair spring once more for the next swing forward. So to and fro it goes, holding the escapement wheel for a moment each time, and thus slowing down the whole train of wheels and preventing the mainspring unwinding with a rush. The toothed wheels of the watch are all carefully geared to give the right speeds to the hour hand, the minute hand, and the second hand

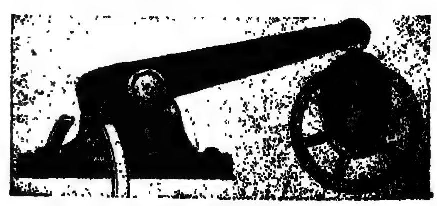
THE SHEARS THAT CUT METAL AS IF IT WERE PAPER

ENGINEERING shops contain a great deal of wonderful machinery. Some of it is very complicated, but there are quite simple machines that do remarkable work. The shears shown here are an example of this. They cut through quite thick metal as easily as if it were paper.



Shears open to receive the metal

A powerful eccentric cam connected with a flywheel revolves and acts upon a roller at the end of a heavy cast iron lever, raising and lowering the lever alternately. As the lever moves a strong, sharp steel plate at the other end is pressed down and cuts quite easily through any metal that may be placed under it. A corresponding sharp steel plate fixed to a heavy block makes the other cutting edge of the shears, which form a pair of powerful scissors.



Shears closed by the eccentric cam

THE WORLD'S BIGGEST LAND ANIMAL

The African elephant is the giant of the land animals. It is, of course, small compared with some of the monsters that lived in past ages, but no other land animal today can approach it in size and weight. It has not been used for man's service to the same extent as the Asiatic elephant, but attempts are now being made to train it to do useful work, and this may save it from extinction. Here we read many interesting things about this very picturesque animal which often weighs six tons and eats eight hundredweights a day.

THE biggest animal in the world is the whale, but he lives in the water. He is far too heavy ever to be able to move about on land. There is, however, one land animal which weighs anything up to six and a half tons, and that is the African elephant, a giant which eats eight hundredweights, nearly half a ton, of food a day in order to support life.

He stands sometimes nearly twelve feet high, and when he wanders into a plantation of growing crops, he not only roots up and eats vast quantities, but destroys far more than he eats. In quite a short time a few African elephants will lay waste a whole area of sugar-cane or tear down a plantation of bananas. The farmers and their families have to flee from the enemy or to escape into the high trees, from which they watch the destruction of their homes and fields.

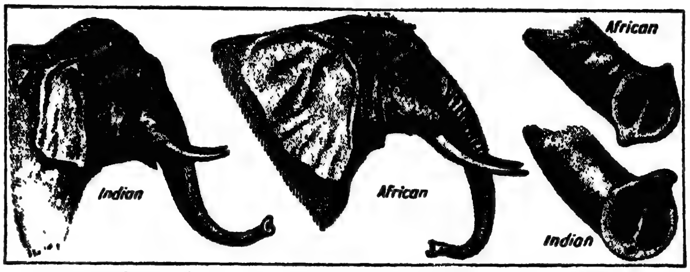
The African elephant differs very much from its Asiatic relative. It has far larger ears, which, when they are not waved forward to catch the sound of danger, lie back, covering the whole of the shoulders of the animal.

Trunks and Ears

The head of the African elephant is much more rounded than that of its relative, the eye is larger, and the end of the trunk instead of having one long finger on its front edge has two, one in front and the other behind. The trunk also is very different, for in the African elephant it appears to be composed of a series of segments like a collapsible telescope. Its skin is darker, its tusks are larger, and its hind foot possesses three nails in place of the four of the Asiatic elephant.

An African elephant's tusk in the British Museum, which measures 10 ft. 2 ins. in length, weighs 228 pounds, or more than two hundredweights. The longest known tusk of an African elephant measures twelve feet all but an inch.

By means of some of the fine films which have been taken in the African forests in recent years, ordinary stay-at-home people, including boys and girls, can know exactly how the African elephant looks and behaves in his native home. He is a fine beast, but unlike the Indian elephant he cannot easily be trained as a beast of burden or to do useful work such as moving and piling logs. In India elephants are caught and trained for these tasks. The African elephant is, however, a richer source of ivory because its tusks are larger and of better quality.



A comparison of the heads, ears and trunks of the Indian and African elephants. Notice the fingers at the ends of the trunks

Mr. J. A. Loring, the field naturalist of the Roosevelt African Expedition, tells us that elephants become so bold that they not only raid the plantations at night, feeding on sugar-cane, maize and vegetables, but they tear down the huts and kill the people living in them.

A Village Terror

"Within two days' march of Lake Albert," he says, "we came to a village near which lived a rogue elephant that had terrorised the people for weeks. He visited the gardens nearly every night and had wrecked several grass huts, destroyed crops, and had killed a man."

A rogue elephant is a solitary animal which for some reason or other has left or been driven from its herd and has developed vicious habits. It hunts alone, and when it comes across human beings is very dangerous indeed.

Animal lovers regret that elephants are becoming fewer, but people living in elephant country know what a menace they are As Africa becomes more and more inhabited, the area in which the elephant can be allowed to exist becomes more restricted.

Some years ago the Government of South Africa decided to destroy the herds of elephants in certain areas in order that the farmers might be able to continue to exist. When only a few animals were left alive these were confined within a certain district and were protected so that they might not be killed off; but after some years had passed the elephants had once more

An African elephant listening with its huge ears

increased so much that they began to break out of their sanctuary and raid the farmers' fields. Once again, therefore, they had to be reduced in numbers.

What the future of the African elephant will be it is very difficult to say, for while some cry out for its destruction, others believe that it may be trained to do useful work, such as ploughing, in districts where heavy rains make the use of tractors impossible for many months of the year and where the horse does not thrive.

A young bull elephant feeding on the tender shoots at the top of a tree

The idea that African elephants cannot be trained is quite wrong. The Romans and Carthaginians of old trained many of them, and African elephants have been used for carrying children on their backs in European zoos. The famous Jumbo was a striking example of this. Indeed the Belgians in the Congo have established an elephant training school at Api, where they have succeeded in taming and training African elephants to do much useful work.

Training the Giant

The keynote of the training system at Api is kindness. No elephant may ever be struck, and any breach of rule on the part of the trainers is punished severely. Whenever an elephant undergoing training obeys an order, or even attempts to do so, it is rewarded with some delicacy, such as a piece of sweet potato.

An elephant has very poor sight and is unable to detect a man at more than fifty yards, but to make up for this its hearing is very acute, and its smell is so sensitive that it can scent a man half a mile away. The huge ears, the span of which, when they are stretched out and measured across the forehead, is often as much as 15 feet, enable the beast to catch the faintest sound.

The African elephant can keep up a speed of fifteen miles an hour for about one fifth of a mile, then it settles down to a steady pace of ten miles an hour and keeps this up for an hour. It is a much faster runner than the Asiatic elephant.

It is the fact that the elephants have such poor sight that enables photographers to get so near to them for the taking of moving pictures. If a herd be approached on the side towards which the wind is blowing, the hunter or traveller can get very near the elephants. A hunter once wagered that he would write his initials on the hind quarters of an African elephant while it was alive, and he actually succeeded in doing so. On the other hand men approaching elephants on the side from which the wind is blowing are very quickly detected.

A Dinner of Elephant

The African elephant is a more dangerous animal than its Asiatic relative, and is far more ready to charge; while the females are said to be more dangerous than the males, and will charge with very little provocation.

Elephant flesh is coarse and rank to the European taste, but the natives of Africa seem to appreciate it, and baked elephant foot cooked in the skin is regarded as a great delicacy. The natives are also very fond of the ears, which they prepare by stewing. The white man is seldom more popular than when he has shot an elephant, for then the natives will come in scores to the feast, falling on the carcass and, if there are enough of them, eating almost the whole of it.

The natives go in great fear of the elephant, for if one of these beasts catches a man it will kneel upon him or pierce him with its tusks, or sometimes pick him up in its trunk and play with him before crushing him to death. The elephant hunter must always find a vital spot with his bullet, or risk terrible danger.

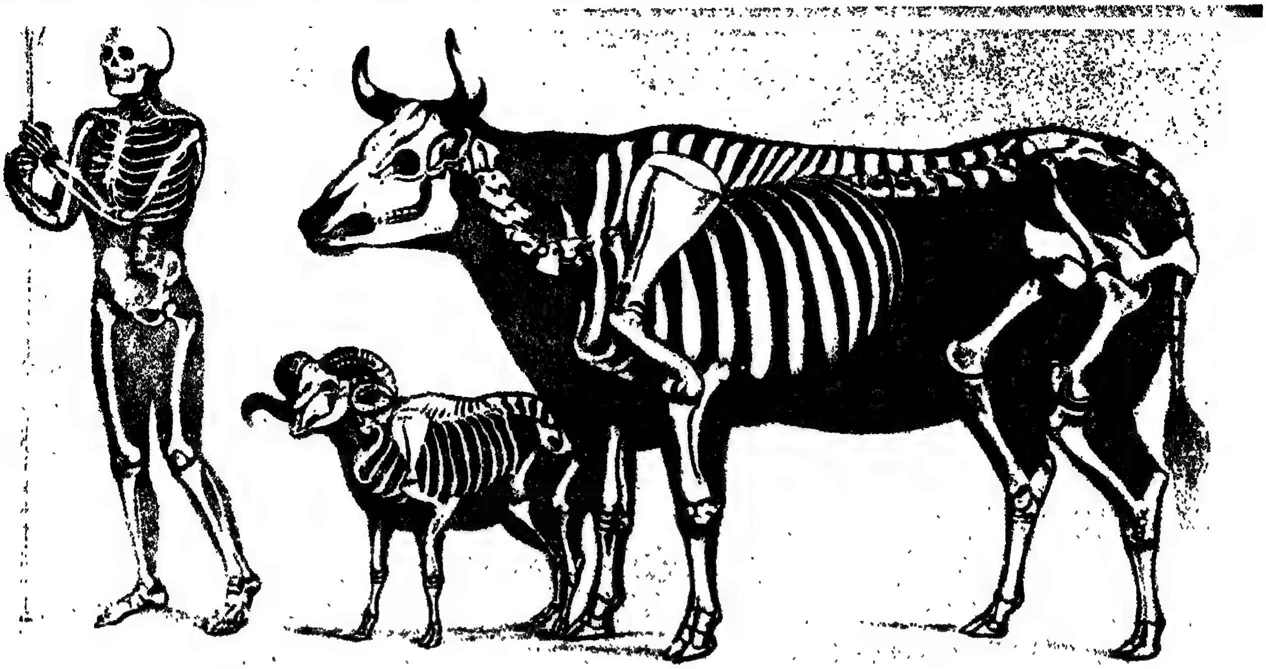
Apart from man the elephant has little to fear from enemies, as his strength and the fact that he usually keeps with a herd combine to make him safe except when very young.

Wild elephants bathing in the Congo with one on the left squirting water over his back

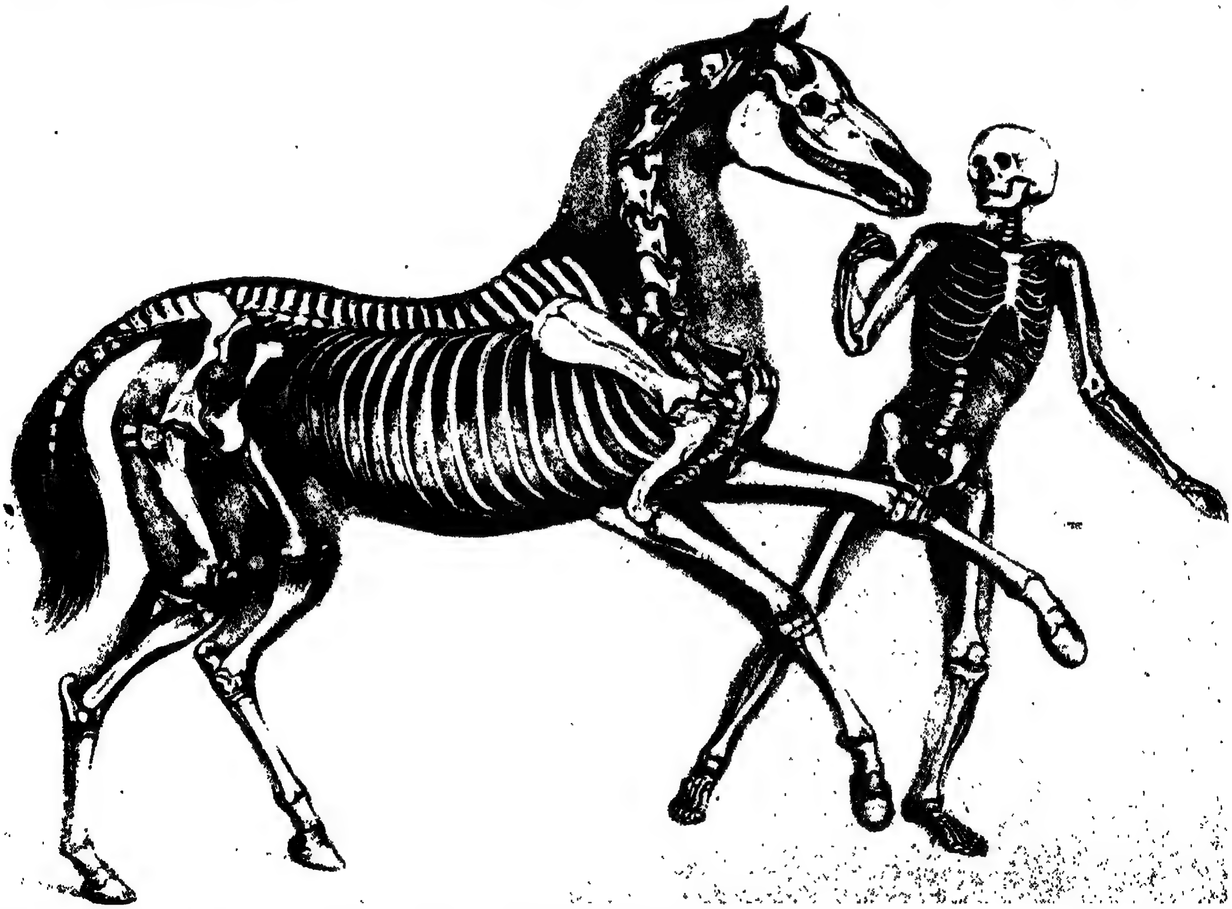
A BEE HELPS A FLOWER TO PRODUCE SEED

Before plants can produce seed which will develop into new plants their flowers must be fertilized. This means that the dust or pollen produced in the anther, a little box on the stamen or male part of the flower, must find its way to the ovary at the base of the pistil or female part of the flower, where the seeds are produced. The pictures on this page show how the bird's-foot trefoil is fertilized by the honey bee. A bee alights on the flower to collect nectar and the keel is pressed down, forcing up the undeveloped stigma at the end of the pistil. As the stigma moves up it pushes the pollen produced by the anthers on to the bee. The bee flies off to another flower, carrying the pollen with it. It reaches a flower where the stigma is mature and ready to receive pollen. This stigma being pressed against the bee's body receives some of the pollen, which germinates and throws out delicate hairs that reach the ovary and fertilize the ovules or eggs produced there. They then develop into seeds, which form in a pod, and the pod dries, splits, and expels the seeds

THE FRAMEWORK OF AN ANIMAL'S BODY



The bodies of ourselves and all the higher animals are built round a solid framework of bone known as the skeleton. There is a backbone, which in ourselves consists of 33 bones jointed together so that, while the backbone can be kept rigid when required, it can also be made very flexible for moving. Here we see skeletons of a man, an ox and a sheep in relation to the soft parts of the body.

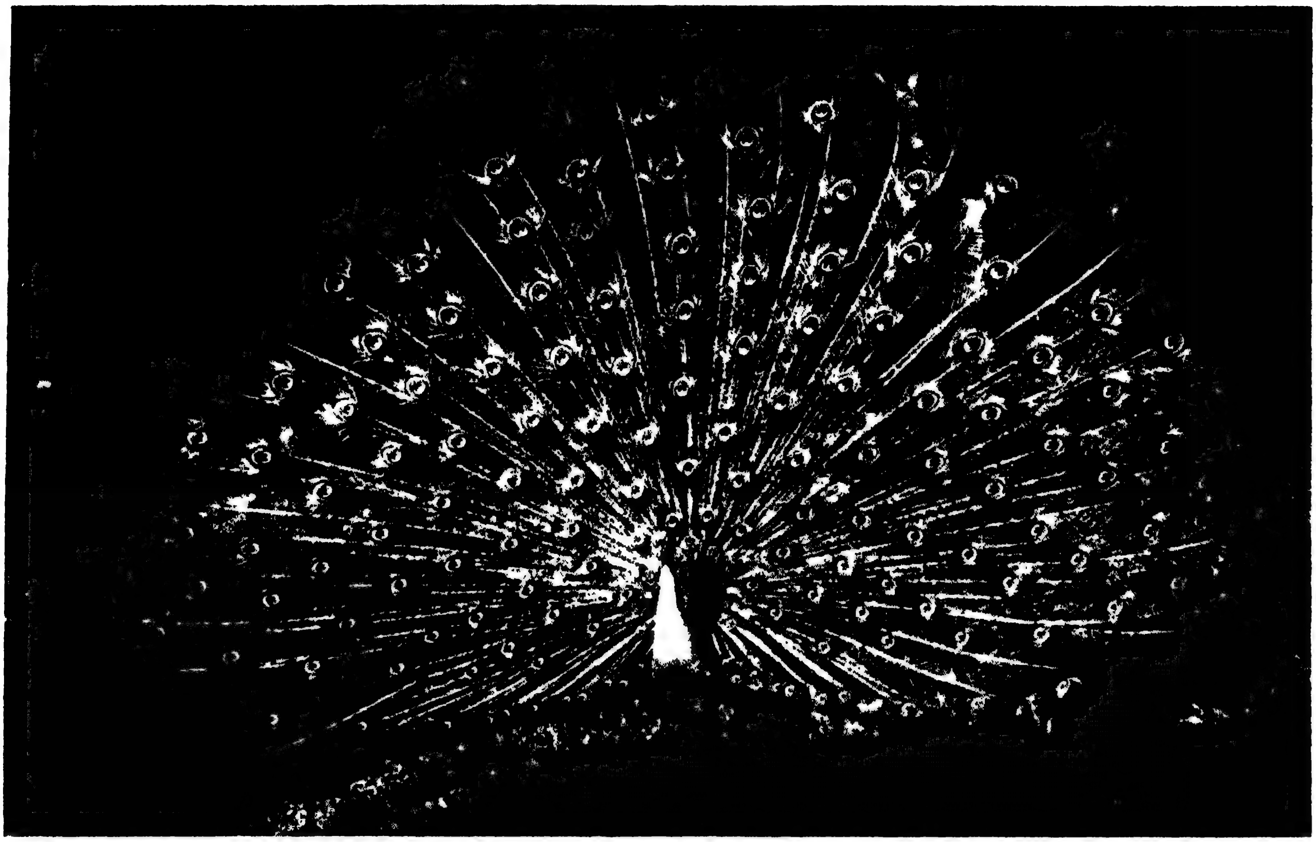


The framework of bone not only enables an animal to retain its shape, just as the steel framework of a modern building determines its form, but it also acts as a protection to delicate organs inside the body. Human beings, of course, generally maintain an upright position and their spine or backbone is erect, whereas the normal position of the backbone of an ox, horse or other quadruped is horizontal. This picture shows a man leading a prancing horse

THE BIGGEST LIVING THING IN THE WORLD

What is the biggest living thing in the world? Most people would answer "a whale," or perhaps "an elephant," but neither reply would be correct. The biggest living thing in the world is this giant sequoia tree, which forms one of the Mammoth Grove in the Sequoia National Park, California. It is over 300 feet high, and contains enough timber to make 30,000 million matches, or a box of 16 for every inhabitant of the world. This wonderful grove of trees in California contains not only the biggest living thing in the world, but the oldest. Some of the giant trees are believed to have been growing for more than 4,000 years. It is a marvellous thought that there should be still living in the world trees that were flourishing when Moses was playing as a little child by the banks of the Nile

THE TAIL OF A HUNDRED THOUSAND PRISMS



The wonderful colours of the peacock's tail are not produced by pigments or colouring matter, but by many thousands of tiny prisms all over the feathers. As the light strikes upon the tail these minute prisms break it up into its seven colours—violet, indigo, blue, green, yellow, orange, red—and then reflect these colours back to our eyes. Indeed, the peacock's tail produces an infinite number of tiny rainbows, and just as no two persons see the same rainbow, as is explained on page 20, so no two persons see the same peacock's tail in exactly the same way

THE WONDERFUL ARCHER FISH

LIVING creatures obtain their food in many curious ways, but certainly there is no method more remarkable than that practised by a little fish that lives in the mouths of rivers in northern Australia and in some of the rivers of the East Indies.

This fish watches for its prey, which generally consists of flies, and when it sees an insect resting on a leaf overhanging the water it goes up quietly, shoots a jet of water from its mouth with astonishing accuracy, and brings the fly down into the water. Then without wasting a minute it darts forward, opens its mouth and swallows the insect. Very rarely does an archer fish miss its mark.

Bringing down a fly with a good shot

About to seize the prey shot down

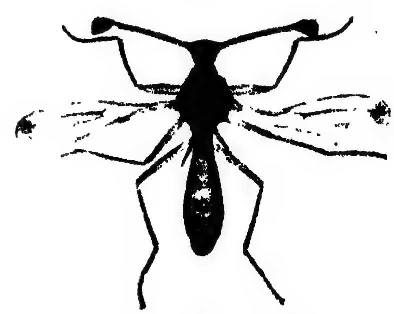
This creature, also known as the rifle fish, is called by scientists Toxetes, which is a Greek word meaning bowman. The fish rarely exceeds a foot in length and weighs less than two pounds, but it makes quite good eating.

The Malays keep the archer fish in a bowl and watch it practise marksmanship.

THE INSECT WITH EYES ON STALKS

ONE of the queerest insects in the world is a little fly that is found in Natal, and a picture of which is given here. Its eyes, instead of being fixed directly in the head, are on the ends of two lateral stalks projecting from the head like two feelers.

In some cases the stalks are not very long, but in others they are quite as long in proportion as the antennæ of butterflies and moths. Curiously enough, in the female the length of these projections is less than that of the male, and in the different species of stalk-eyed flies the projections vary a good deal in length.



The stalk-eyed fly of Natal

On the creatures' first pair of legs there are jagged edges, and these it uses for crushing other insects that form its prey.

WHY WE ARE NOT HURLED OFF THE EARTH

There are all sorts of natural forces which are operating in the world in which we live, and which might prove disastrous for us were it not for the fact that they balance one another. Our planet rushes round on its axis at a great speed, and we should very soon be hurled off into space by the force known as centrifugal force, were it not that this is counteracted by another force, gravitation, which holds us to the Earth. Here are some interesting facts about centrifugal force

On tracks where motor cars, motor cycles or cycles are to be raced at high speed, and also on the outside bends of railway curves and on many roads, the track or roadway, instead of being horizontal like an ordinary road, is banked up at an angle, and in the case of a track used for very fast cars the angle is very great. Why is this?

The reason is that there is a force known as centrifugal force, which if the track were horizontal would cause the cars instead of going round to rush off the track in a straight line. The word centrifugal, which may seem a difficult one, means "flying from the centre," but it is an unfortunate name to have given to the force, which is not really a flying from the centre at all.

First of all let us understand what centrifugal force is. If we take a basin of water and move it round and round rapidly the water inside will start rotating and will gradually rise at the sides of the basin till at last it is thrown out over the edge.

As long as the water touches the side of the basin it is kept inside the vessel, but directly it gets above the side and

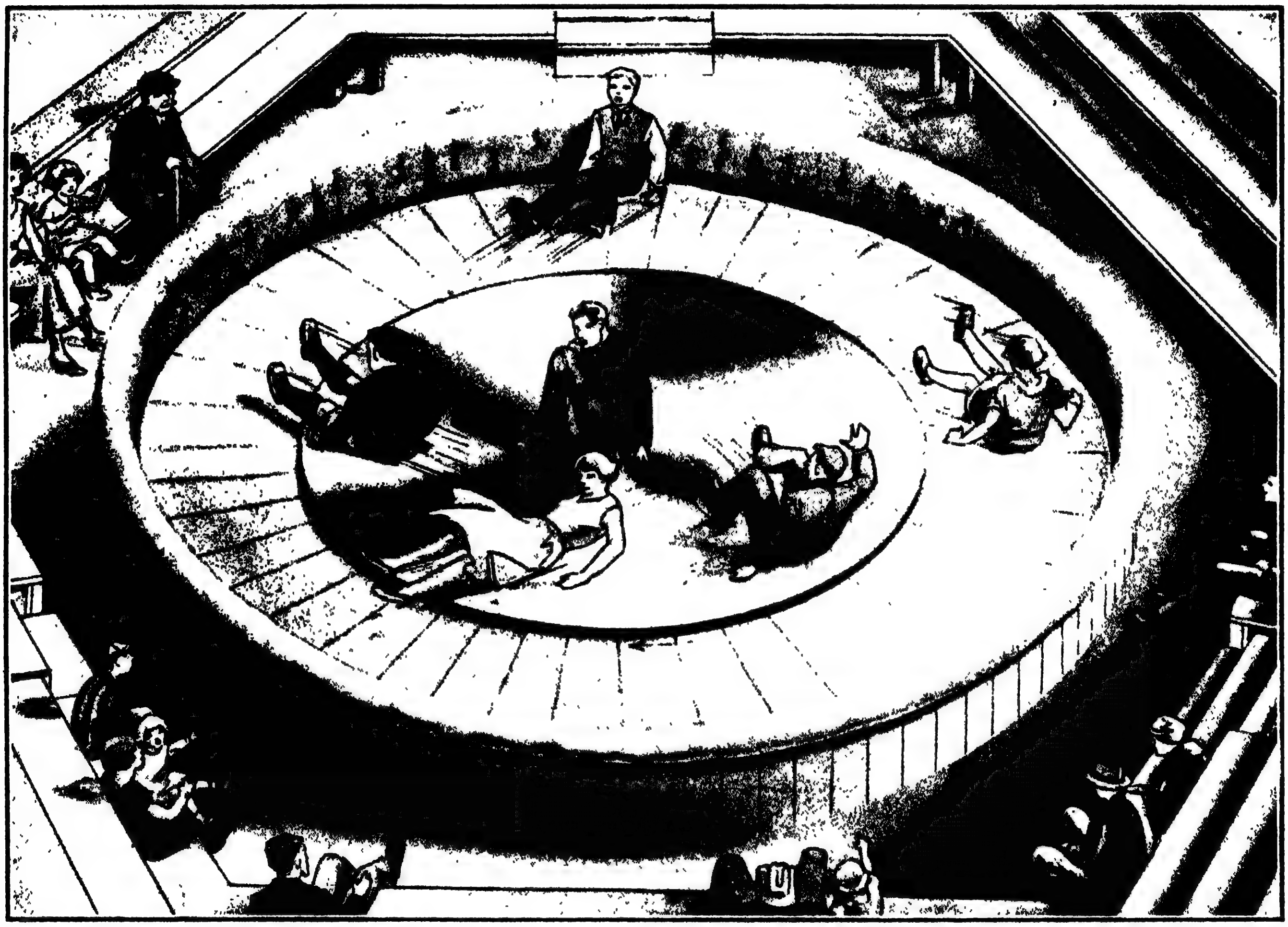
If the Earth's gravitation or pull suddenly ceased to act we should all be hurled off the world into space—not only ourselves, but all the animals, houses, ships, trees, stones, water, and indeed everything that was not firmly rooted in the Earth's crust. This would be due to centrifugal force, resulting from the rotating motion of the Earth. Fortunately gravitation overcomes centrifugal force

there is nothing to stop it the fluid is thrown out for a considerable distance. It is centrifugal force that causes the water to be hurled out in this way. We might try this experiment out in a yard or garden.

Now let us carry out another experiment. We tie a ball or stone to a string and swing it round and round. The stone or ball will move in a circle, but if the string suddenly breaks or we let go, the stone goes off in a straight line. It is centrifugal force that carries it away. But so long as we hold the end station and then starts suddenly with a jerk we are jerked back. We realise from this that when a body is in motion it seems to want to keep on moving in the direction in which it is going, while if it is at rest it seems to want to remain at rest. As Newton put it, " Every body continues in its state of rest or of uniform motion in a straight line, except in so far as it is compelled by external force to change that state."

This property which all bodies possess of resisting any attempt to start them if they are at rest, and any attempt to direction it may happen to be travelling at the moment of release.

Exactly the same thing happens with the water in the basin. When we rotate the basin, the water is set in motion and each drop of water would go off in a straight line, but it is prevented from doing so by the sides of the basin. Being free it rises higher and higher in the basin, and eventually escapes over the side. Centrifugal force is, therefore, not really a flying from the centre, but a force by which all bodies moving round another body tend to fly off at a



The Joywheel used to be a very popular side-show at exhibitions. People stood or sat on a platform, which was then set whirling, and as it went faster it threw the people to the side by centrifugal force. Of course, a padded barrier saved them from injury. The spectators obtained a great deal of amusement, although probably they did not realise that this was a truly scientific toy

of the string another force known as centripetal force, which means " centre seeking," keeps it moving in a circle and prevents it flying off.

We notice when we are swinging the ball round that we have to pull on the string all the time to prevent the stone flying away. Now what is the explanation of these curious facts ?

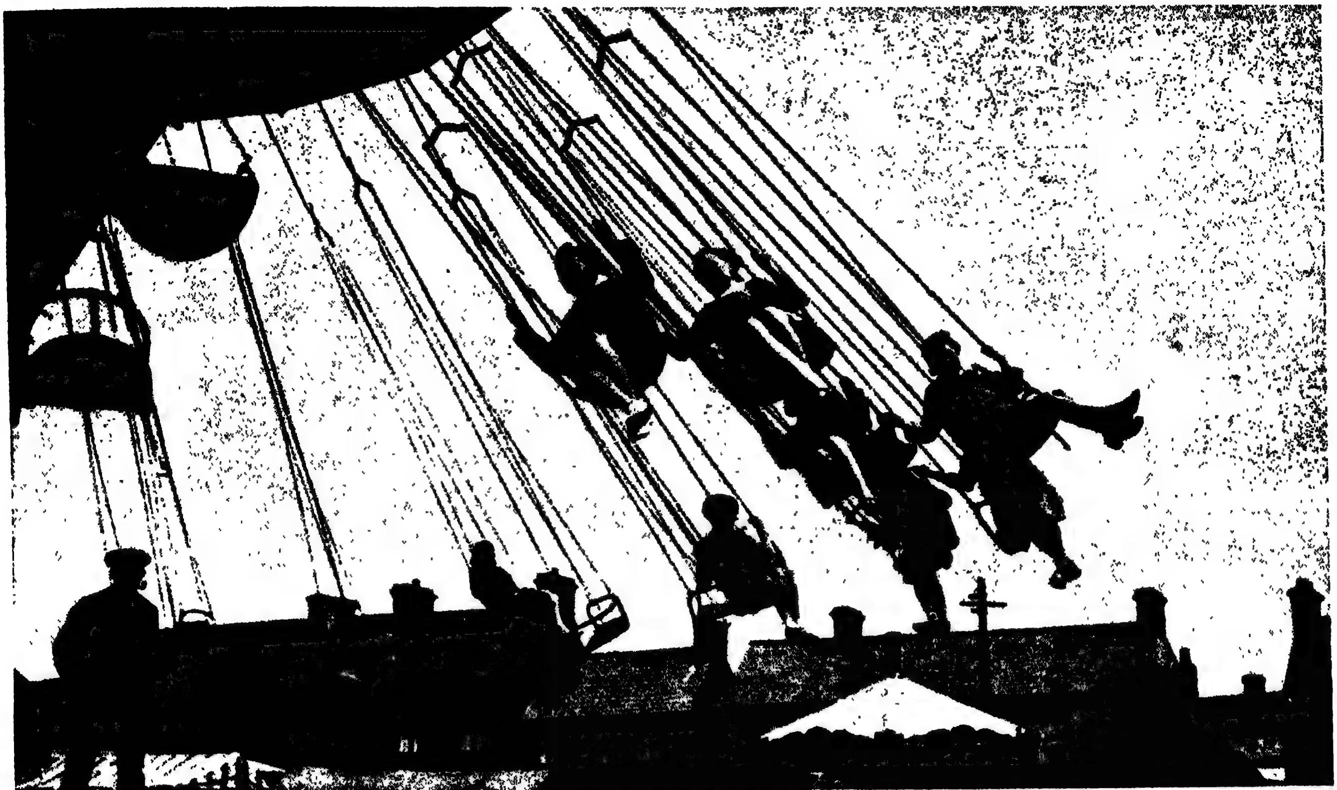
Sir Isaac Newton has explained the matter in what is known as his " First Law of Motion." We know that when we are riding in a train facing the engine, if it pulls up suddenly we are shot forward. On the other hand, if the train is standing still at a railway stop them if they are in motion, is called " inertia." Inertia has to be overcome each time we start or stop a car.

We are now able to see why the water in a rotating basin is thrown out over the edge, and why the stone swung round and round goes off in a straight line if the string is released. When we swing the string, at every point in the stone's progress, if it were free, it would travel off in a straight line, but it is unable to do so because the string is pulling it towards our hand. Immediately, however, the stone is freed from the string or the string is released, the stone goes off at a tangent in whatever tangent, that is in a straight line from the circumference of the circle in which they move.

In the case of the string and stone it is counteracted by the centripetal force, but as soon as that force ceases to operate, as when the string is broken or released, centrifugal force has its way.

It is quite clear now why in the case of a curved racing track for fast vehicles, like the motor track at Brooklands, the roadway must be banked at a sharp angle. If centrifugal force is not to take the motor cars or cycles off the track the road-

TWO FAMILIAR EXAMPLES OF CENTRIFUGAL FORCE



Many familiar examples of centrifugal force are to be seen in everyday life. One of the most striking is that shown here. The "Chairoplane" with aerial chairs attached to a rotating device is always popular at fairs. As the apparatus rotates faster and faster those sitting in the chairs are whirled out farther and higher till at last they go round almost horizontally. Of course, if the chains snapped they would be hurled to a great distance in a straight line, just as a ball whirled round on a string flies off if the string breaks.

Here is another example of centrifugal force. The picture shows men of the Royal Horse Artillery turning a corner at high speed with their gun. Here, again, the tendency is for horses, men and gun carriages to go on in a straight line, but when by an effort the horses are turned both men and horses have to lean inwards to overcome the action of centrifugal force, which would carry them forward. It is, for this reason, much easier to gallop forward in a straight line than to turn or ride in a circle.

way must be inclined so that the centrifugal force may be counteracted. It is like the stone and the string, only instead of pulling the stone so as to prevent it flying off, we push the car towards the centre to counteract the centrifugal force.

Railway tracks are also banked in a similar manner at all sharp curves. One of the shows at a circus is often a cyclist wheeling round and round an absolutely perpendicular track, he himself, with his machine, riding horizontally. It is centrifugal force that prevents him falling to the ground.

Centrifugal force can be seen in action in many places. Cyclists riding round a corner, have to bend inwards to prevent themselves going on in a straight line. They are bringing centripetal force into play to counteract the centrifugal force. At village fairs, the flying boats attached to a roundabout, as speed is increased, swing farther and farther to the horizontal. If the iron connecting them with the roundabout were to snap, the boats would be hurled far off in a straight line.

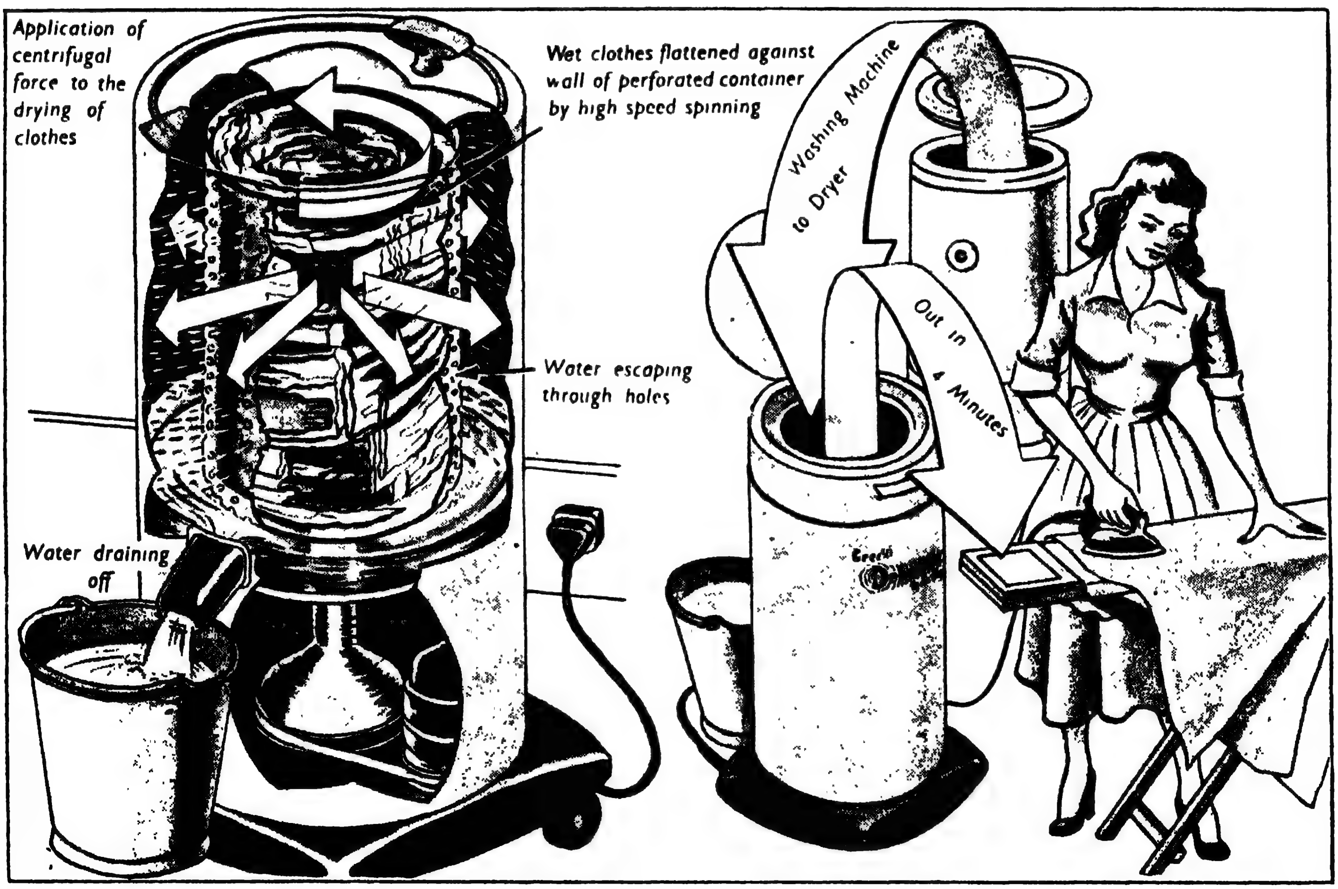
For many practical purposes, too, centrifugal force is used. It is by its aid that the cream is separated from the milk as the fluid is whirled round in cream separators. In centrifugal pumps, a rapidly driven fan inside the pump drives the water into a discharge pipe; the vacuum caused by its departure makes room for other water to be sucked up, so that a continuous stream of water is delivered by the pump.

This powerful force has to be taken into consideration in all cases of rapid rotary movement. If the rotor of a steam turbine, for example, were to revolve beyond a certain speed, the thousands of blades fixed into its surface would be torn out by centrifugal force and do immense damage. When Sir Charles Parsons, the inventor of the Parsons steam turbine, made his early experiments he took great risks, for he ran his turbine more and more rapidly till its blades were torn off. This was to discover how fast a turbine could turn without centrifugal force damaging it.

We must bear in mind that the globe on which we live is whirling round continuously at a very rapid rate; at the Equator the speed is over a thousand miles an hour, and were it not for the force of gravitation everybody and everything on the Earth would be whirled off into space. The greatest tendency to fly off is, of course, at the Equator, and it gets less towards the Poles, but where we are reading this book it is so great that we and the book and the house in which we are living, and all the things in the street, could be hurled off the Earth. Gravitation acts as a centripetal force and counteracts the centrifugal force due to the Earth's rotation.

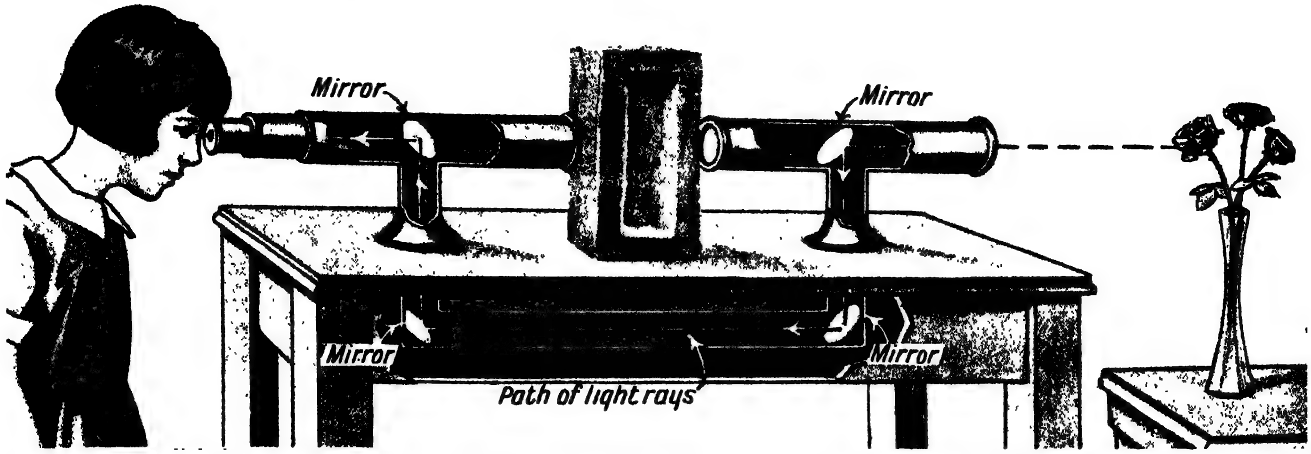
It must be remembered that this centrifugal force causes a body to weigh less at the Equator than at either of the Poles, because the force is greater there. It has been calculated that a body weighs one-289th less at the Equator than at the Poles. If the Earth's speed were increased seventeen times, objects at the Equator would weigh nothing. This increase of weight as we get nearer the Poles owing to the lessened centrifugal force has nothing to do with the increase of weight at the Poles due to the flattening of the Earth. A body on the Earth's surface at the Poles is a little nearer to the centre of the Earth, where the pull of gravitation is exercised, than it is at the Equator, and as the pull increases the weight also increases.

Inventors have often tried to overcome gravitation. We may be thankful that they have never been able to do it so far as the whole Earth is concerned.



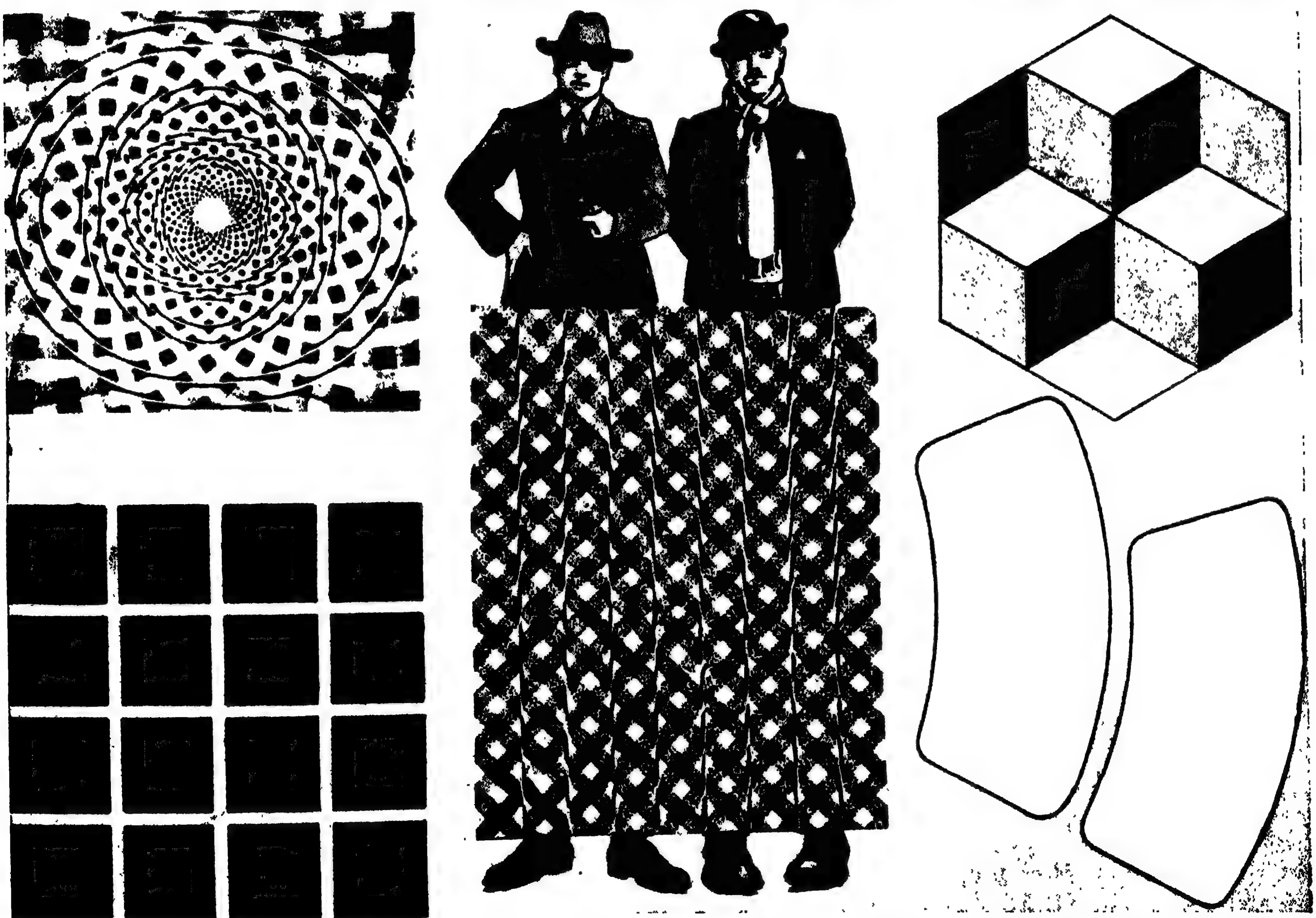
This drawing was prepared from material supplied by the Simplex Electric Company, and shows how the principle of centrifugal force is used to dry household washing. The wet washing is placed in a perforated container which is revolved inside an outer casing by an electric motor. As the container whirls around at high speed, the washing is thrown outwards and flattened against its sides. The centrifugal force created by the rotating container then throws the water off the wet clothes and other articles, leaving them perfectly dry in a matter of minutes. All of which is a wonderful improvement upon hanging washing on a line!

HOW YOU CAN SEE THROUGH A BRICK



There is a familiar saying that you cannot see through a brick wall, but here is a way in which you can, at any rate, see what is on the other side of a brick and appear to be looking through it. On the table are two telescope-like tubes, and when you look into the eye-piece you see quite clearly what is on the other side of the brick, although it is hidden when you look without the telescope. The stands of the two tubes are continued under the table and linked together by another tube. Four mirrors are arranged at angles, as seen, and the object looked at—in this case a vase of flowers—is reflected from mirror to mirror, so that what the observer really sees is not the flowers themselves, but the reflection of the flowers in one of the mirrors

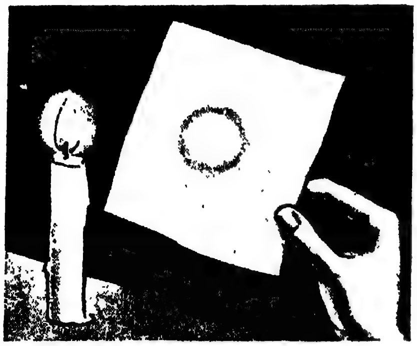
THINGS THAT ARE NOT WHAT THEY SEEM



Appearances are often deceptive, and here are some remarkable examples. The legs of the men in the middle picture do not appear straight, but if you hold the picture horizontally and look along the legs you will see that actually they are straight. Similarly, the figures in the top left-hand corner do not appear circles; they seem to be ellipses. You will find they are circles if you test them with compasses. In both cases the eye is distracted by the plaid pattern. Look at the two figures in the bottom right-hand corner. Who would think they were the same size? Yet they are. Their position deceives the eye. In the bottom left-hand corner are some black squares separated by white lines. As you look at these the angles where the lines cross appear to be grey. In the right-hand top figure we seem to be looking down upon three cubes, but after a minute or two our vision appears to change and we are looking up at them

THE SCIENCE OF A LIGHTED CANDLE

The wonders of modern science which seem so astonishing to-day are all the result of experiment. For centuries men have been testing and proving things, and one experiment has led to another, until marvellous discoveries have been made which can be put to practical use in industry and everyday life.



The circular flame of a candle

A little experiment is worth a great deal of book knowledge, and every boy and girl can become a practical scientist in the sense that he or she can perform scientific experiments.

To do this it is not necessary to have elaborate apparatus and expensive chemicals.

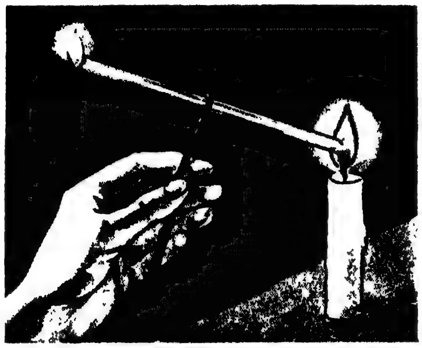
Take, for example, such a familiar object as a candle. Here are a number of experiments which we can perform and which will teach us a good deal of science. It seems a very ordinary thing to light a candle, and the flame does not appear very interesting. But as a matter of fact the flame is well worth studying, as Michael Faraday, the great scientist, discovered long ago.

Though the candle is burning the whole of the flame itself is not alight.

Water collected from a burning candle

You can prove this by holding a sheet of white notepaper for a moment or two horizontally in the lower part of the flame near the wick. When you remove the paper you will find, as in the first picture on this page, that there is a black, sooty ring, and outside this a ring where the paper is scorched. Why is this? Well, the scorched ring is caused by the burning of the vapour of the flame, and the sooty ring consists of lamp-black from the particles of carbon in the bright section of the flame. But inside the black ring the paper is left white, because there the vapour rising from the burning candle remains unburnt.

The candle-flame, if you look carefully, will be seen to consist of three parts, a faint outside part, where the vapour is burning, a luminous section inside this, which consists of incandescent particles of carbon, and then a



Collecting gas from a candle flame

faint bluish section right inside, which consists of unburnt combustible vapour from the fat of the candle.

If you hold a piece of thin glass tubing with one end in the faint blue of the flame, you can draw off this vapour and light it at the other end of the tube, where it burns with a faint

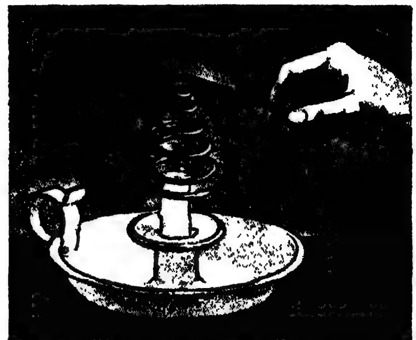
Carbon dioxide produced by a candle flame

light. Hold the glass tube with a piece of bent iron.

It is easy to put out a candle by blowing it, but you can also extinguish the flame by cooling it without blowing it. Take a piece of copper wire, such as you can buy at the ironmonger's, make a spiral, and then lower it while it is quite cold over the flame, which will go out, because the wire absorbs the heat. If, however, you heat the wire beforehand and repeat the experiment, the flame will go on burning.

When a candle is alight hydrogen gas is burning. You can prove this by holding a tumbler over the flame. Eventually little drops of water will form, and finally trickle off the tumbler. These are due to the hydrogen gas, which is responsible for the flame, combining with the oxygen of the air. Water, as we know, is made up of oxygen and hydrogen gases.

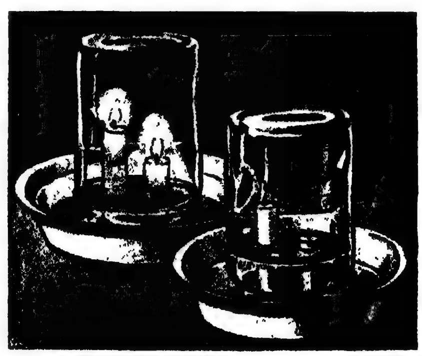
If you burn a candle in a jam jar,



A novel way of putting out a candle

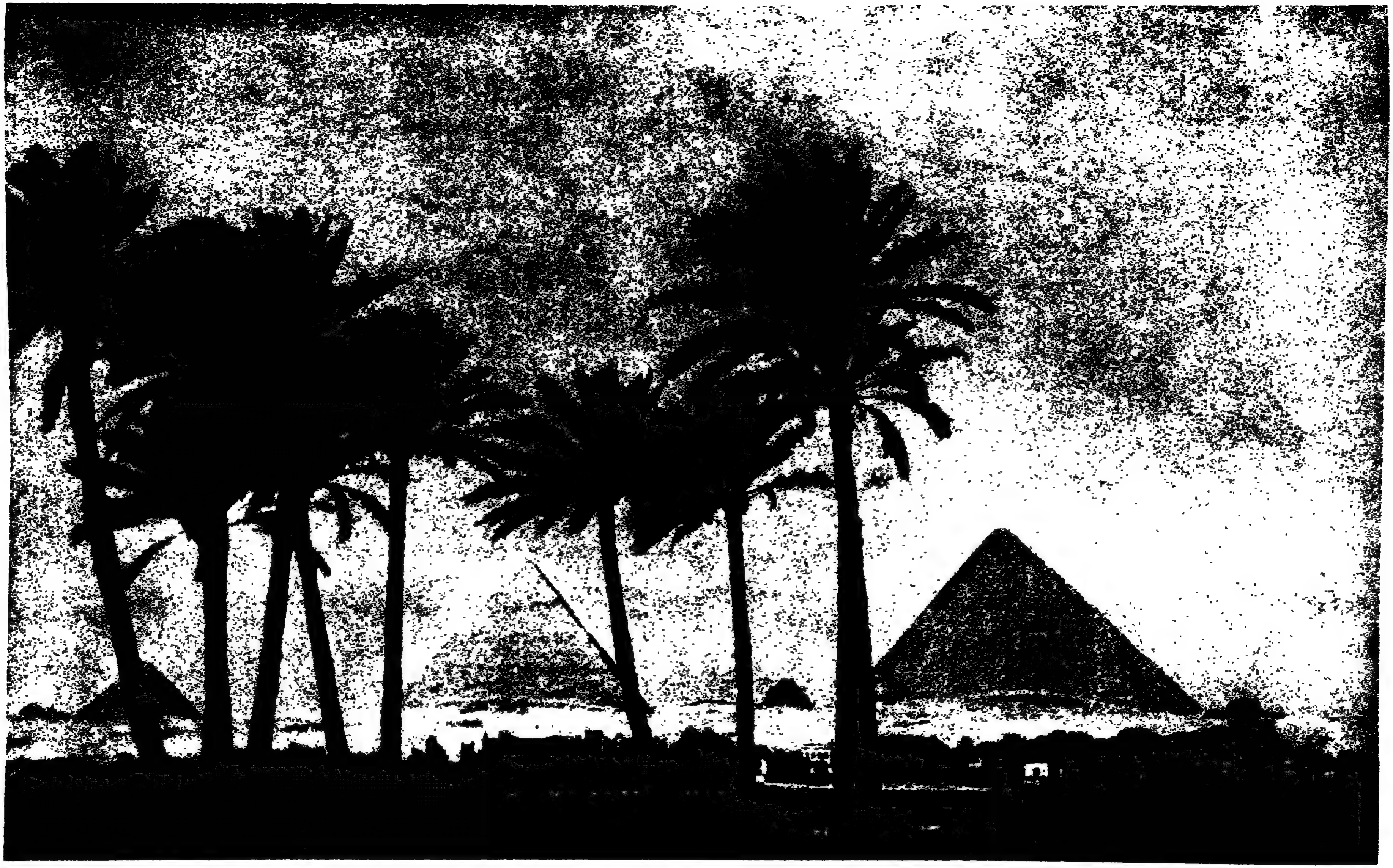
covering the jar over so that no fresh air can get in, the flame will soon go out. The carbon of the candle-fat, when burning, combines with the oxygen of the air, forming carbon dioxide gas, and this gas will not support combustion. You can prove the gas is in the jar by removing the candle and pouring in some clear lime water. The carbon dioxide will change the lime in the lime water into chalk, making the liquid milky, and gradually the particles of chalk will sink to the bottom of the jar.

That a candle uses up air when burning can be very simply proved. Stand two lengths of candle in a bowl, fixing them to a piece of wood if necessary. Pour in water, light the candles, and invert over them a glass jam jar, seeing that its edges are below the water.



Showing that a burning candle uses up air

Soon the candles will go out, and when the jar becomes cool the water will rise in it. The candles in burning have used up some of the oxygen of the air, and the water rises to take its place. About one-fifth of the vacant space of the jar will be occupied by the risen water.



H. A. Fawcett.

ONE OF THE SEVEN WONDERS OF THE WORLD: THE GREAT PYRAMID AND ITS NEIGHBOURS

The three huge Pyramids at Gizeh, about 5 miles south-west of Cairo, are the largest of the seventy-five royal tombs of this shape still standing on the edge of the Egyptian desert. The only survivor of the Seven Wonders of the Ancient World, the Great Pyramid (right), tomb of Cheops or Khufu, with a height of 481 feet, contained 88¼ million cubic feet of stone, weighing 6,840,000 tons, in 2,300,000 blocks averaging 2½ tons each, piled in 210 horizontal courses upon 12½ acres; 100,000 men were employed on its construction for three months in the year for 20 years. The Pyramid of Chephren or Khafra (centre), 454 feet high and containing some 60 million cubic feet of rock, shows at its tip a relic of the polished stone with which all the pyramids were once entirely cased. The Pyramid of Mycerinus or Menkaura (left), smallest and latest in date of the three, was 219 feet high. The three kings interred here were all of the IVth Dynasty (about 25 centuries B.C.)

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WONDERS of ANIMAL & PLANT LIFE

HOW PLANTS RESEMBLE ANIMALS

Very few people realise how much alike in their nature are plants and animals. Most of us think of plants with their flowers and fruits as something entirely different in character from ourselves and other animals. But, as a matter of fact, the similarities are very striking, as we read here. If more of us realised this, we should be kinder to the flowers. We should be as sorry to see a rose trampled upon as to see a dog ill-treated

There is a great deal of truth in what a kind and gentle lady wrote of some flowers that had been sent to her. "The roses are here by my side. I have just clipped the stems and given them fresh water, and they are giving me in return the very sweetest possible fragrance. I wonder if you feel towards flowers as I do? They always seem to speak of a great and wonderful Creator who is kind and loving as He is great. Heaps of other things they tell me—that a person who is delighted in giving flowers must himself feel and appreciate their wonder.

"I always feel a little sorry for the flowers, so beautiful in themselves, subjected to the rough handling of the market men and flower women I think that they must often feel very hurt about it all. Perhaps that is why they appreciate the new surroundings and are endeavouring to prove their contentment. I should like to think that to be the reason."

Plants are Sensitive

The plants may not feel pain and pleasure in the same way as we do, but scientists have proved they are definitely sensitive and that a tree shows some response to the passing of a cloud overhead.

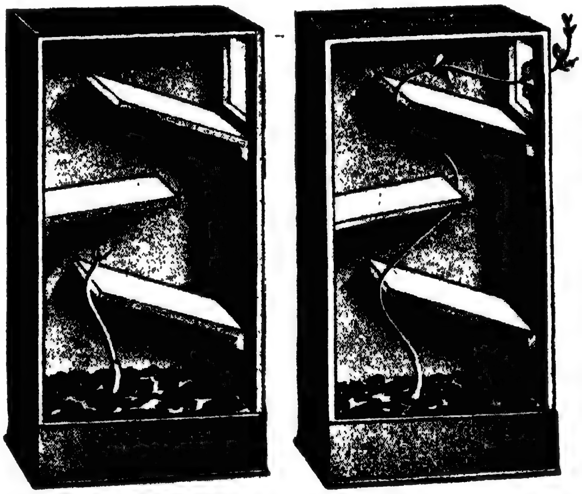
Let us think for a moment of the many ways in which a plant resembles an animal. In the first place it is a living creature which takes after its parents in character and is affected by the surroundings in which it lives. If those surroundings are healthy then the plant becomes strong and sturdy, and just as healthy children and men and women show by their smiles that they are happy, so the plant by its beautiful leaves and its lovely flowers, indicates that it is responsive to the pleasant surroundings.

We, in common with all the animals, have to breathe in order to keep alive, and the same thing is true of the plant. Deprive the plant of oxygen and it withers and dies just as an animal does. The plant must breathe continuously if it is to live.

We take in the air through openings in our body—the nostrils—and the plant also takes in air through openings, though in its case they are so small that a microscope is needed to reveal them.

Breathing indeed is the first thing done by every animal and every plant as soon as it is born, and the breathing must be continued so long as life lasts.

Then just as we must eat in order to grow, so the plant must do the same. Without food neither an animal nor a plant can increase or develop or produce anything. Of course the method of feeding is different in the two cases, for while an animal takes in food that is ready for digestion, the plant absorbs substances which are not yet food. It makes these substances into food in its body, and then digests them. But though the process is different the substances that nourish the plant are very much the same as those that build up the animal.



Two stages in an interesting experiment to show how green plants always grow towards the light. Anyone can make a box of this kind and try the experiment for himself

Plants also grow in the same way as animals. In both cases the bodies are made up of tiny parts known as cells, and the plant or animal increases in size not by the cells themselves becoming bigger and bigger, but by the number of cells increasing

Plants too, like animals, have weapons with which to defend themselves from enemies. A man has his fists, a cat or a lion has claws, a dog has teeth, a snake has poisoned fangs. And so a blackberry bush has its prickles, a rose has thorns, a deadly nightshade has poison, a cactus has spines and a nettle has stinging hairs which are used in the same way as the fists, claws and poison fangs.

The fight among the plants is indeed quite as fierce as that among the animals. Leave the garden untended for a month or two, and the weeds will have grown up and killed many of the garden flowers that are not natives of the soil, and are thus less fitted for the battle of life in those particular surroundings. How often we see a tree that has been killed by ivy climbing up the trunk, strangling the tree and drawing from it its life nourishment.

As we know, among the animals there are males and females which become the parents of similar animals, and so in the plant world there are males and females, and these produce young plants which are like themselves.

Care for the Young

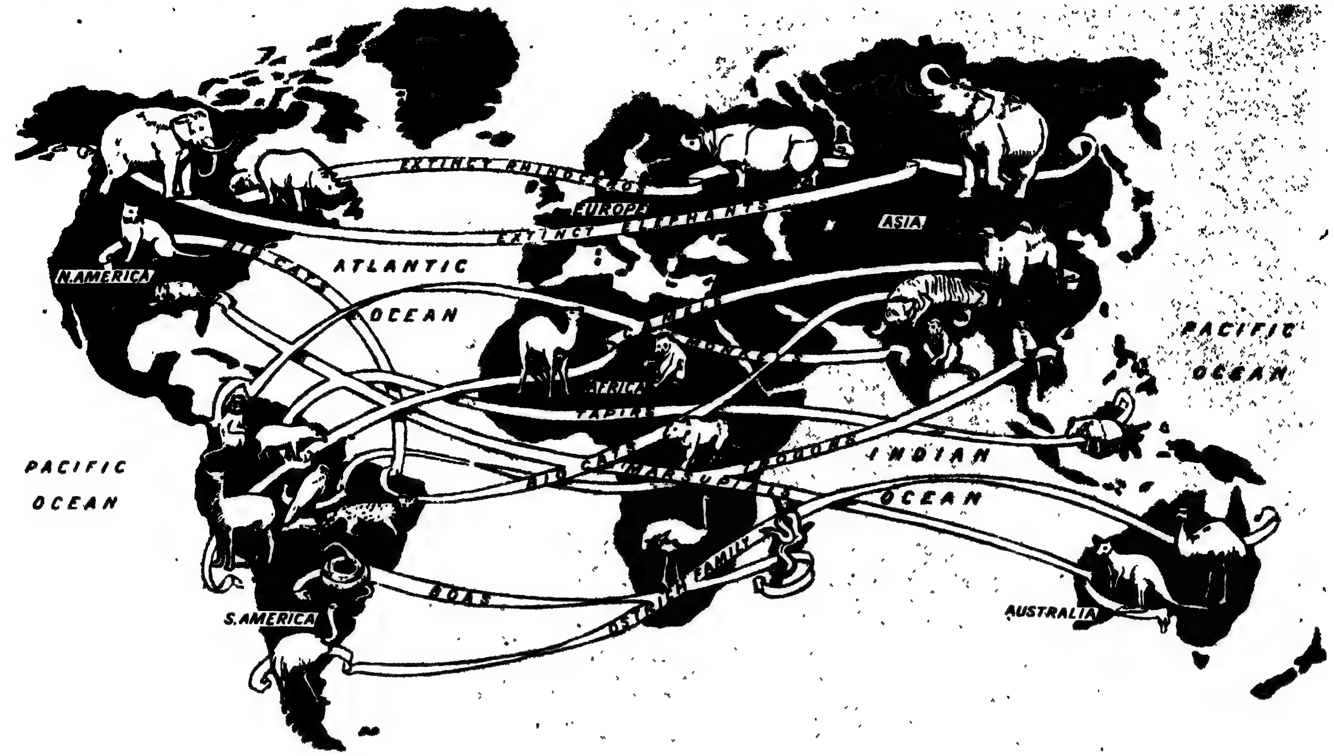
The animal parent in most cases cares for its young, and the plant parent does the same. Sometimes it does this by protecting the young offspring (that is the seed), so that enemies shall not destroy it. The coconut is a good example of this. In other cases by throwing the seed to a distance or fitting it with a parachute arrangement for travelling, it enables the young plant to get a good start in surroundings where it will be able to obtain sufficient nourishment.

Animals work at certain hours and then need rest; and in the same way the plants work generally by day, taking in substances and manufacturing them into food, and when the sun goes down suspend their operations and take a rest just as animals go to sleep.

There is great competition among the animals, for life is a fierce struggle. We find this when we are in competition with other boys and girls at school, whether it be in an examination or in sport, and we find it still more so when we grow up and have to earn our living. In the same way there is much competition among the plants. They have to struggle for their existence; they often crowd one another and only the strongest live.

If we remember all these things we shall never ill-treat a plant any more than we shall ill-treat an animal or a child. We shall be kind to the flowers.

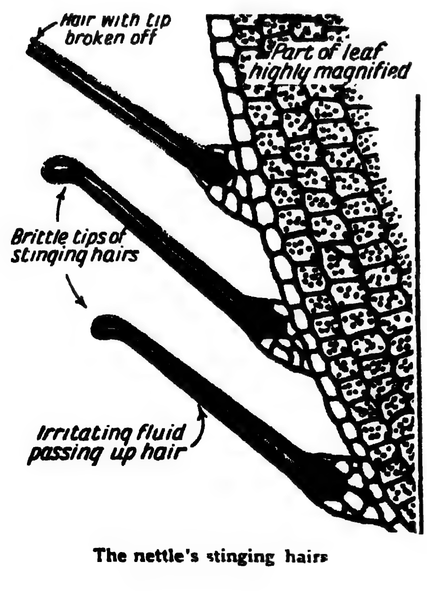
ANIMAL LINKS IN THE OLD AND NEW WORLDS



Scientists believe that at some time in the past the American Continent has been linked with Europe, Africa, Asia and Australasia, because almost identical or related species of animals exist in the different continents. In this picture-map we see some of the links. The remains of extinct elephants, for example, are found in North America and the north of Europe and Asia. The rhinoceros, too, though now extinct in America, once lived there, as we know by remains that have been found. The big cats, represented by lions, tigers and leopards in the Old World, have their counterpart in the pumas and jaguars of the New. The llama of South America is a family relation of the camels of Africa and Asia. The ostrich of Africa has its family connections in the emu and cassowary of Australia and the rhea of South America. The birds known as trogons, too, are found in the Old and New Worlds. Monkeys are found in South America, Africa and Asia, and tapirs in South America and the East Indies. Boas are found in South America and Madagascar. Scientists believe that it is impossible for almost identical species to have arisen in different parts of the world independently

THE NETTLE'S STING

WE do not generally think of the stinging nettle, so common in our fields and lanes, as being a very interesting plant. Indeed, we regard it as a great nuisance, and every time our hand or leg smarts through touching its leaves



The nettle's stinging hairs

we wish the plant did not grow in England at all.

But, as a matter of fact, the stinging nettle is a very interesting plant, and its means of defending itself against enemies is both ingenious and effective. The leaves are covered with many hairs, and these have at their ends rounded tips which are very brittle. When we touch the nettle and a hair comes in contact with our skin the tip breaks off, and the sharp jagged edge that is left pierces our skin.

The hairs are not solid, but are really little tubes containing an irritating corrosive fluid which the plant produces. Directly our skin is pierced this fluid pours in from the hairs, and acts like a poison, setting up inflammation, and making our flesh smart and tingle.

A Good Defence

Naturally, we are very careful the next time we come near any nettles not to touch them, and so they escape to a degree they would not do if they had not developed such an ingenious method of defending themselves against foes.

Some of us may have noticed that if the nettle be grasped firmly we are not stung, and the reason is that instead of the brittle tip being broken off the hair is fractured lower down, and then there is no sharp or jagged edge to pierce our skin, and inject the corrosive fluid into our blood. The liquid simply runs away and does no harm.

A TREE'S HIDDEN PARTS

WHEN we look at a tree we do not see it all, for there is nearly as much underground as above. The roots search in all directions for water, and cover as much space as the boughs and branches

What a tree is like underground

TWO KINDS OF AFRICAN RHINOCEROS

Africa is the home of two kinds of rhinoceros, known respectively as the black rhinoceros and the white rhinoceros, although there is no great difference in their colour. Both species have two horns The black rhinoceros, shown here, is the smaller of the two. Its eye is nearer the nostril than in the white rhinoceros, and its upper lip is curled at the end so that it can grasp herbage. The male of this species stands 5½ feet at the shoulder. The horns vary in length, and are often broken or worn. Generally the front one is the longer

This photograph of two specimens of the white rhinoceros was taken by night in Africa. The white rhinoceros is the largest member of its family, and often reaches a height of 6½ feet at the shoulder and a length of 14 feet from snout to tip of tail. In some cases the front horn is over five feet long, and the great ambition of a South African chief in the old days was to possess a staff made from such a horn. In both species of African rhinoceros the sight is bad, but this is made up for by remarkably keen scent and hearing

A BIRD THAT CARRIES A FISHING NET

The pelican is not a British bird, but we are all familiar with it because it is seen in our zoos, and is often kept in public parks. Its wonderful beak, which has a huge fishing net attached to it, is its chief feature, and the bird is, as we read below, one of the cleverest of all feathered fishermen. It is a good swimmer and flier

The pelican is certainly one of the most remarkable birds living, and when we see for the first time the bird securing its food we get a real surprise. The upper part of the beak is rounded at the end, and a kind of keel that runs along the entire length ends in a claw-like hook which helps the bird to catch its prey.

But it is the lower part of the beak that is so extraordinary. It is fitted with a capacious bag which is not very conspicuous when the bird is at rest, but is capable of holding a great deal of food.

The pelican lives mostly on fish, and when it is hungry goes into the water, opens its beak and scoops up fish, water and all. The water escapes over the side of the beak, but the fish is caught in the bag, and where there are plenty of fish a pelican will collect a whole bagful, and only swallow his food when he returns to shore.

Different species of this bird are found in various parts of the world. Flocks of thousands are seen in North Africa and along the banks of the Nile, and there are also American pelicans, which are to be found in large flocks. Many of the African pelicans make their way to Southern Europe during the summer months, where they breed. Sometimes they get as far north as Germany. In Hungary flocks of five or six hundred arrive, and then spread themselves all over the country for the nesting season. Later they again assemble in flocks, and then when winter approaches fly off to Africa once more. There are also European pelicans, and species peculiar to the Far East and Australasia.

Pelicans are really most marvellous fishermen. They do not dive, but seek their food in small and shallow waters, either of a river or a seashore. They seem to be quite indifferent as to whether the water is fresh or salt. No fish, however small, escapes their keen eye, and even when they are flying high in the air, if they see a fish swimming in the water far below they dart down upon it with unerring aim.

When seeking food they sometimes stand in the water, and at other times go out swimming after the fish. When large numbers of them are swimming on lakes they look like great beds of water lilies. On returning to shore they sit in the sunshine, preening their feathers, and then fly up into the trees and, perching upon the branches, go to sleep. The trees then look as though they were covered with massive white blossoms.

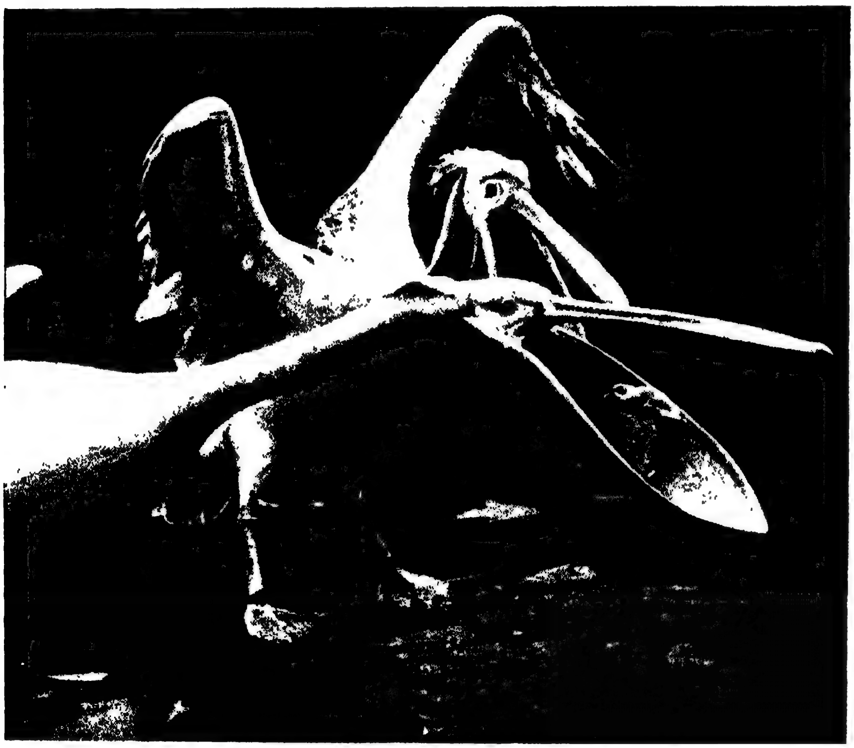
When there are thousands of pelicans together, their method of catching their prey is ingenious. They assemble in some place where the water is of a suitable depth and arrange themselves in a semicircle or row and then advance and gradually drive the fish towards the shore.

Although the pelican feeds mostly on fish it is not above seizing and swallowing a bird. Ducks have often been seen to disappear down the capacious throat, and some time ago spectators in St. James's Park were surprised to see a pelican nip up a young duck and swallow it.

The naturalist Audubon has given a graphic account of the American pelican, which is very similar in appearance and habit to that of North Africa.

"Lightly they float as they marshal themselves and extend their lines; and now their broad, paddle-like feet propel them onwards. In yonder nook the small fry are dancing on the quiet water. Thousands are there, and the very manner of their mirth making the water to sparkle, invites their foes to advance. And now the pelicans at once spread out their broad wings, press closely forward with powerful strokes of their feet, drive the little fishes towards the shallow shore, and then, with their enormous pouches spread like so many bag-nets, scoop them up and devour them."

After it has been feeding the pelican will often dry its bag by opening its beak and stretching the bag over its chest, just as bathing costumes and towels are spread on sands or bushes to dry in the wind.



A pelican in a London park which has just caught a fish

The great bag on the pelican's beak

THE WRECK OF THE WHITE SHIP

The loss of the White Ship, with the heir to the English throne on board, is one of the most dramatic stories of English history, and has been recorded in both prose and verse. The story is well worth telling again, and here is the narrative compiled from the most authentic information that has come down to us from the records of the past. We may well believe the story that after losing his son and heir Henry the First never smiled again

THE average person knows very little about King Henry the First and his reign. But two things are familiar to most of us. We all know that Henry was called Beauclerc or "Fine Scholar," and we also know that his son and heir, Prince William, was drowned when the White Ship was lost in the English Channel.

With regard to Henry's scholarship, no doubt he was much better educated than the average man of his class at the time in which he lived. He is said to have been a good Latin scholar, and to have spoken English as well as French, but we are also told that he did not read much, and he certainly could not write, for the first English king able to sign his name was Richard the Second.

A King Who Snored

Of course, those who care to look into the matter find out many other interesting things about Henry. In appearance he was short, thick-set, and dark, and he was physically very strong. His eyes were bright, and when he slept he snored heavily He did not overeat, as so many did in that day, nor did he drink to excess. It is unfortunate for him that he should have died through eating a dish of lampreys, which his doctors had forbidden, for people have got the idea from this fact that he was a glutton Possibly the lampreys were not too fresh, and it may really have been ptomaine poisoning he died from after a week's illness.

He often joked, but he could be very cruel, and rarely, if ever, forgave an injury. If he praised a man it generally meant that that man would be ruined before very long.

He once quoted in the hearing of his father, William the Conqueror, the old proverb: "An illiterate king is a crowned ass." But although he prided himself somewhat on his learning, he got far more pleasure out of field sports than out of study. Hunting, indeed, was his favourite pastime, and in a park at Woodstock he kept quite a zoo, with camels, lions, lynxes, and a porcupine.

Probably the event that affected Henry's life and character more than anything else was the loss of his son and heir. Because of his sad and sudden end a good deal of romance has centred round Prince William, but he does not seem to have been a very attractive young man. Certainly he was no friend to the English people, and had been heard to say publicly that if he ever came to reign over those miserable Saxons he would yoke them like oxen to the plough. Such an attitude towards the conquered race did not promise easy times should William live to succeed his father.

As the boat came alongside the sinking ship a distracted multitude jumped into her and she was swamped

Henry had been at war in France, and King Louis of France and Count Fulk of Anjou had been his enemies, but he won peace not only by fighting but by the use of money and by skilful management of his opponents. He married his son, Prince William, to Fulk's daughter, and this had the effect of detaching Anjou from the French cause. Then Henry concentrated his forces to fight Louis, and at the Battle of Brenneville he not only put the French king to flight but captured his standard. Peace followed, and Henry now determined to return to England. This was in December, 1120.

The Fatal Request

Henry, with his son William, several of his children, and the Norman barons of England, prepared to cross the Channel. A fleet was assembled at the port of Barfleur, but as it was on the point of starting one Thomas Fitz-Stephen went to the King of England and, offering him a mark of gold, addressed him in these words:

"Stephen son of Erard, my father, all his life served thy father by sea. It was he who steered the vessel in which thy father embarked for the conquest of England. My lord the King, I supplicate thee to grant me

the same office. I have a ship called La Blanche Nef (that is the White Ship) which is well rigged and manned."

Henry answered that he had already chosen a ship for his passage to England, but that in consequence of the request of Fitz-Stephen he would entrust to that mariner's safe conduct his sons William and Richard, his daughter Maude, and all their attendants.

It was still daylight when the fleet stood out to sea. The weather was calm and fine, and the vessel which carried the King was the first to set sail, a south wind gently helping the ships across the sea.

In response to a request from the men, Prince William had given three casks of wine to the captain and sailors of the White Ship, and these appeared to have drunk so heavily that they became somewhat fuddled, and there was a little delay in starting. The vessel did not get away till later in the evening, a considerable time after the King had sailed with the other ships. In the hold of the White Ship were some casks of wine and the royal treasure, but there was no other cargo, and it is quite probable that the ship was too light owing to lack of ballast.

A Moonlight Voyage

In order that there might be no difficulty with the navigation of the ship, three pilots were taken on board, and fifty experienced rowers assisted it on its way, while an armed band of marines formed the crew. Thomas Fitz-Stephen was himself at the helm, and the ship made a fine start, with a bright moon shining from a clear sky on the dancing sea.

The White Ship was steered along the coast in the neighbourhood of Barfleur, the mariners, stimulated by the wine which they had drunk, pulling stoutly at the oars and endeavouring to catch up with the King's ship.

It was said that some knights and monks, observing that the vessel was overcrowded by riotous headstrong youths, had gone ashore again at Barfleur. It was also stated that when the soldiers boarded the ship they drove the regular rowers from their benches in a very disorderly way, and jeered away the priests on the shore who, according to the pious practice of the day, would have blessed the voyagers and sprinkled holy water on the vessel about to start.

Whether that be so or not, the White Ship went gaily off to song and the shout of revelling. But although the rowers pulled valiantly, the pilot seems to have steered at random. At any rate, he could not have used his usual skill, for when the merriment was at its height the craft suddenly crashed on to those treacherous rocks which lie beneath the surface of the water and are known as the Raz de Catteville.

If the rowers had been less energetic the worst results of the disaster might have been averted, but the ship was going swiftly, and when she struck the rocks her starboard was stove in with a fearful crash, which suddenly brought the revellers to a sense of reality. The water gushed through the opening made by the rocks, big waves washed over the deck, and as the torrent poured below numbers were drowned.

The Cry from the Sea

The awfulness of the situation was realised at once, and a great cry went up from all those on the White Ship, which it is said was heard in the King's vessels already far away at sea. No one there, however, suspected the cause of the cry; they thought it must be the sound of sea-birds screaming.

Had it been low tide, when the weed-covered rocks became bare, there might have been hope for some at least of the ill-fated victims of the White Ship, but it was high tide and the rocks were covered with surf. Attempts were made with boat-hooks to hold the ship to the rocks and prevent her sinking, but all efforts were fruitless. The water continued to pour in, and in a few minutes the ship, with her screaming, writhing, gasping company, went down.

What of my lord, the King's son," asked Fitz-Stephen "what has become of him?"

When the ship first struck, some of the cooler persons had managed to lower a boat, and into this was placed Prince William with some of his friends. The boat was getting away safely from the danger spot when a shrill female voice rang out amid the terrible din. It was the sound of William's favourite sister Maude, and it is to his credit that he insisted that the boat should put back to rescue her.

But those on the sinking White Ship were frantic with terror, and as the boat came alongside once more a distracted multitude jumped into her, and she was immediately swamped. All those who had been in the boat were drowned. A struggling mass of frantic, drowning people was all that was left of the proud ship which a few moments before had been making its way to England amid gaiety and song.

A writer of the period wailing on account of this tragedy wrote: "Doomed! Doomed to the abyss! Purple and fine linen to rot in the depths; children of kings to be food for fish. The nobles, the wealth, the glory, the grace of form, all covered by the ocean."

Fitz-Stephen's Question

Thomas Fitz-Stephen, the master of the White Ship, had been thrown into the water with the others. He sunk once and then rose to the surface, when seeing the heads of two men who clung to a yardarm, he said; "What of my lord, the King's son; what has become of him?"

"We have seen nothing of him," was the reply, "nor of his brothers or sister, nor of any of their companions."

"Woe is me!" exclaimed Fitz-Stephen. "It were shame and wretchedness to survive!" And he sank to rise no more.

The two men clinging to the yardarm were Geoffrey de Laigle and Berthold, a butcher of Rouen. They prayed, they spoke to one another encouragingly, they longed for day as only shipwrecked mariners can do.

That winter night was very cold, and the weaker of the two survivors, Geoffrey de Laigle, soon became exhausted and lost his grasp of the spar which had supported him. Commending his companion to the care of the Almighty he sank and was never seen again. The sole survivor of that proud company which had set sail was the butcher of Rouen, perhaps the least important of all those who had embarked in the White Ship from Barfleur.

Wrapped in his sheepskin coat he managed to support himself in the cold

sea until daybreak, when he was seen by some fishermen, who immediately went to his rescue and pulled him into their boat. He was taken ashore and there told the story of the tragedy, to the horror of all those who heard.

One of these was a kindly old prelate who, when the White Ship put off, had lingered on the shore pouring out his blessings on the craft and its living freight. He had seen the white sail disappear in the gloom, had heard the singing and the merry laughter of those on board, had heard, too, the cry of anguish that went up when the loaded ship struck upon the treacherous rocks. Whether he knew what the cry meant we are not told, but he continued to watch and pray until, in the morning, he heard from the rescued butcher what had really happened.

It was not long before the evil tidings spread, for bad news always travels fast. Fragments of the wreckage were washed up and dragged on to shore, including, so the chroniclers say, the royal treasure. The bodies of the victims were cast up for many succeeding days on beaches far away.

The evil tidings were soon carried across the Channel, and the news was speedily known at Henry's court, but no one dared tell the King that his son had been lost at sea. It was not so very long ago that that son had been taken to France to win his spurs and to be acknowledged by the barons as Henry's rightful heir. The King was proud of the young man, and now how could the news be broken to him? The courtiers went about in agony. They dared not appear happy, and yet they were afraid to show their misery in the royal presence.

A Little Child Brings the News

At last the courtiers had an idea. They took a child of Count Theobald's and having tutored him as to what he was to say and do, they sent him into the King's presence to break the news to Henry.

The child went in weeping and threw himself at the King's feet. The monarch was naturally surprised and, raising the child, asked him why he wept, and then the boy, reciting the lesson he had learnt, told the King that the White Ship had been lost at sea with all on board.

Henry staggered and fell into a faint. At the very height of his triumph this terrible thing had happened. He was a victor on the field of battle, he was successful in diplomacy, he had strengthened his throne, and he had secured the succession of his favourite son, only to find that all his hopes were dashed to the ground.

The courtiers went forward and after a time they raised the King and led him to his private chamber, but none dared speak to him, and there they left him to his woe, to the terrible bitterness of his memories and his lost hopes. Never again, the old chronicles tell us, was Henry seen to smile.

But it was not only the King's personal hopes that sank in the cruel waves off Barfleur; the course of history was affected, too, for the death of the heir apparent cut off the lawful succession to the throne, and England was to know later the misery of civil war resulting from a disputed succession.

At the time, however, the loss of Prince William did not seem a grievous catastrophe to the English. As already told, the Prince had thrown out hints of the harshness with which he would treat the English when he succeeded to the throne, and it is not unnatural, therefore, that their chroniclers show little compassion for the misfortune of the Norman king and his nobles. They call the loss of the White Ship a divine vengeance, a judgment of God, and dwell with much satisfaction on the idea that in the wreck there was something of the supernatural; otherwise, they ask, how could such a tragedy have occurred in calm weather on a tranquil sea? They remind us of Prince William's words and of his malevolent designs towards the English nation.

"The proud youth!" exclaims a contemporary. "He thought of his future reign, but God said, 'It shall not be so, thou impious man; it shall not be so'; and it has come to pass that his brow, instead of being circled by the crown of gold, has been dashed against the rocks of the ocean. It was God Himself Who so ordered that the son of the Norman should not again see England." The English still regarded their king as a foreigner.

Mrs. Hemans, the poetess, has told the story of the loss of the White Ship in the verses beginning:

The child went in weeping and threw himself at the King's feet, at which Henry was naturally surprised

The bark that held a prince went down,
The sweeping waves rolled on;
And what was England's glorious crown
To him that wept a son?
He lived—for life may long be borne,
Ere sorrow break its chain;
Why comes not death to those who mourn?
He never smiled again!

There stood proud forms before his throne,
The stately and the brave;
But which could fill the place of one,
That one beneath the wave?
Before him passed the young and fair,
In pleasure's reckless train;
But seas dashed o'er his son's bright hair—
He never smiled again!

Hearts, in that time, closed o'er the trace
Of vows once fondly poured,
And strangers took the kinsman's place
At many a joyous board;
Graves, which true love had bathed with tears,
Were left to heaven's bright rain,
Fresh hopes were born for other years—
He never smiled again!

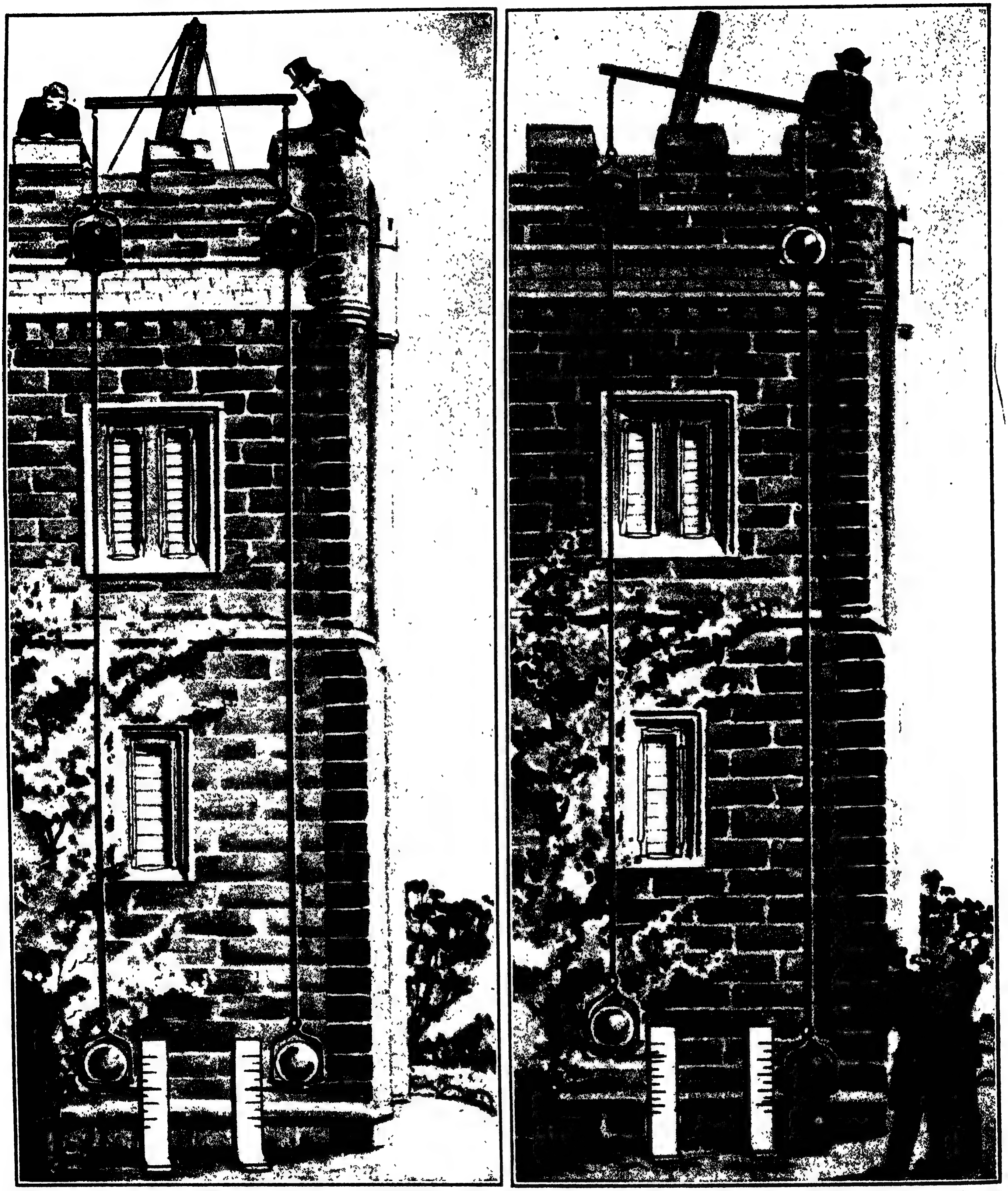
Henry married again, but he had no children by his second wife, and he had to resign himself to the bitter knowledge that he would leave no male heir to the crown of England.

A Usurper Seizes the Crown

His daughter Matilda, who had been the wife of the German Emperor, became a widow, and Henry brought her back and determined to make her successor to his throne of England and his dukedom of Normandy. But no female sovereign had sat upon an English throne since the time of the Ancient Britons, and both English and Normans were opposed to this scheme of placing the nation under the government of a woman. Henry, however, was a powerful king and a bitter enemy, and so, although the barons murmured in secret, they dared not oppose his will openly till after his death.

Then they sided with the usurper Stephen, and so Henry's daughter lost the crown that her father was so anxious to place upon her head.

WEIGHING THE EARTH ON A TALL TOWER



These pictures show one of the ways in which the Earth has been weighed by men of science. From each end of the horizontal beam of a balance placed on top of a tower was hung a pair of scale pans, one far below the other. In the upper pans were placed two glass globes filled with quicksilver, and in the lower pans two empty globes. The balance remained horizontal, as seen in the left-hand picture. The scientists then transposed the full and empty globes on one side of the balance, as shown in the right-hand picture, whereupon the beam tilted on that side, because the quicksilver, being nearer the Earth's centre, was attracted more by gravitation. When a large leaden sphere was placed under this lower globe of quicksilver it was drawn down still more, and by measuring the amount of tilt, the attraction of the lead ball, and the attraction of the Earth, the Earth's density and weight could be calculated

WONDERS of LAND & WATER

DIFFERENT WAYS OF WEIGHING THE EARTH

It is easy enough to weigh a pound of apples, or even a ton of coals, but how can the Earth be weighed? We cannot take it up and put it into the pan of a balance, nor can we hang it to a steelyard. Nevertheless men have found out ways of weighing the Earth, and some of these are described here. The results arrived at are about the same in all cases, and we know beyond the shadow of a doubt that the weight, or, to speak more correctly, the mass, of the Earth on which we live is nearly six thousand million, million, million tons

When we speak of an object as weighing one pound, we mean that it has in it one pound of material, or, as men of science say, the mass is one pound. Mass is the quantity of matter in a body, and weight is the pull which the Earth exerts upon it. For ordinary purposes of everyday life, mass and weight are the same, though when we want to be really accurate we find that this is not always the case.

Of course it is easy to weigh a small object, such as a loaf of bread, a sack of coals, or even a railway wagon, by putting it on the scales. But how can the Earth be weighed, or, to be strictly accurate, how can we find out the mass of the Earth, that is, the amount of matter in it? Obviously we cannot put it in the scales, but men of science have found out various ways of discovering the Earth's mass, and they all give very nearly the same result.

The World's Weight

The Earth, as a whole, is just a little over $5\frac{1}{2}$ times as heavy as a ball of water of the same size. This means that its weight or mass is 5,852,000,000,000,000,000,000 tons.

It seems a very wonderful thing for men to be able to tell us this. Let us see how they went to work.

The first serious attempt to weigh the Earth was made in Scotland. Just as the great mass of the Earth pulls or attracts a smaller body, so the great mass of a mountain will do the same. Men of science therefore took a plumb-line and suspended it near the foot of Mount Schiehallion, in Perthshire, and measured how much the plumb-line was drawn out of the perpendicular by the mountain's attraction. Then they took the plumb-line to the other side of the mountain and again measured the deviation very carefully.

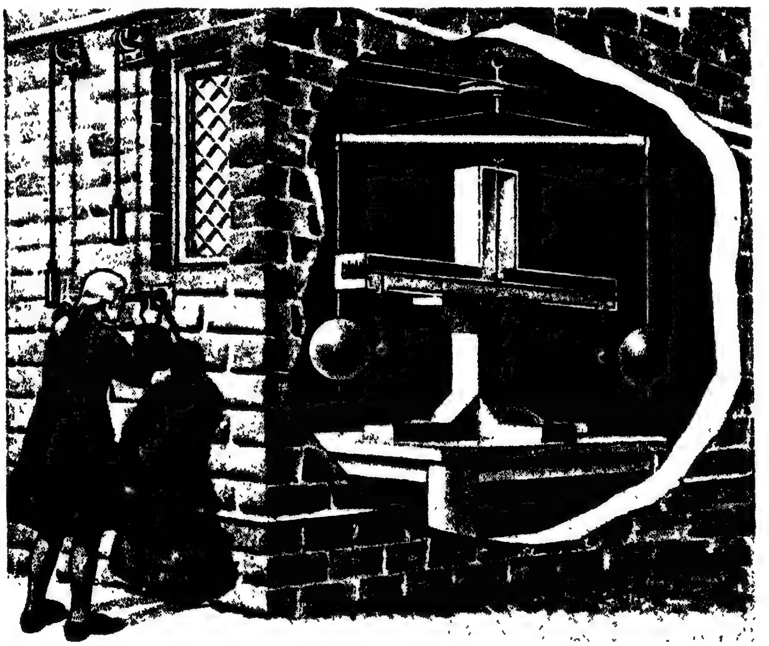
Next they worked out as accurately as they could the size and mass and then the density of the mountain. Density, of course, means the closeness of the material in an object, as compared with water, which is reckoned as 1. They found that the density of the mountain was $2\frac{1}{2}$ times that of water; in other words, the mountain was $2\frac{1}{2}$ times as heavy as a body of water occupying the same space would be.

Now, they reasoned, if the mountain attracts the bob of the plumb-line to a certain specified degree, and the Earth attracts it (as they found it did) $1\frac{4}{5}$ times as much, then the density of the whole Earth must be $1\frac{4}{5}$ times that of the mountain. By multiplying the density of the mountain, which was $2\frac{1}{2}$, by $1\frac{4}{5}$, therefore, they found the density of the Earth to be $4\frac{1}{2}$ times that of water.

Various other experiments of the same kind were soon carried out more accurately, when the Earth's density was proved to be a little more than $5\frac{1}{2}$ times that of water.

Having discovered the density of the Earth as a whole, it was quite easy to work out its weight or mass. The circumference and diameter were known. From these were worked out the size of the Earth, that is, the number of cubic miles it occupies, and then it was easy to calculate what a similar-sized ball of water would weigh, which, multiplied by $5\frac{1}{2}$, gave the mass of the Earth.

But this is not the only way in which the Earth can be weighed. Spheres of the same specific gravity attract small objects on or near their surface with a force which is in proportion to the diameter of the spheres. Thus a ball four feet in diameter attracts with twice the strength of a ball of the same material two feet in diameter; one of six feet attracts three times as strongly, and so on.



Here we see how Henry Cavendish weighed the Earth by suspending from each end of a delicate balance a little ball of lead. He brought near these balls two large spheres of lead and noted how much their attraction twisted the balance. By elaborate calculations he then worked out how much more the Earth attracted the little balls than did the large spheres of lead, and so calculated the density of the Earth. It was then easy to find its mass or weight

Using a Model

Now the Earth is nearly 42 million feet in diameter, or just over twenty million times that of a ball two feet in diameter. If, then, we make a small model of the Earth two feet in diameter, having the same average specific gravity as the Earth, it would attract a small object such as a pea or a shot with one 20-millionth part of the attraction of the Earth.

But we are setting out to discover the specific gravity of the Earth. We therefore use a globe of lead and find out how much that attracts an object as compared with the Earth. Then, by a series of minute calculations, the specific gravity of the Earth can be worked out and eventually its mass or weight.

It was this method that was carried out in 1798 by Henry Cavendish, the wealthy grandson of a Duke of Devonshire. He was a queer man, who used to leave notes on the hall table telling the servants what he wanted for dinner.

They had strict instructions to keep out of his sight on pain of instant dismissal.

But he was a very clever man, and was described as "The richest of all the wise men, and probably the wisest of all the rich." He gave his life up to science, and one of the great things he did was to weigh the Earth by means of a very delicate balance known as a torsion balance.

How Cavendish Weighed the Earth

"Torsion" is a word that means "twisting," and a torsion balance is one in which the horizontal arm is suspended by a very thin wire or fibre, which enables the arm to twist horizontally in any direction. Cavendish's method of weighing the Earth with this apparatus was as follows:

He suspended from each end of his balance a little ball of lead 2 inches in diameter, and each weighing rather more than a pound and a half. Then he took two large balls of lead, each 12 inches in diameter and weighing 350 pounds, and hung these from another horizontal arm which also could be moved round horizontally.

First of all the big balls were suspended at right angles to the torsion rod; then they were gradually brought round till they almost touched the little balls. The delicate torsion balance twisted slightly as the small balls were attracted by the large ones. The angle through which the horizontal balance moved was carefully measured, and then the two large balls were turned round in the opposite direction, until they nearly touched the opposite small balls. Again the balance was twisted and the angle of deviation measured.

Cavendish was then able, by elaborate and careful calculations, to find out how much more the Earth attracted the little balls than did the large balls of lead, and from these figures he worked out the density of the Earth, making it about five and a half, as had been done by the other method of weighing the Earth. Then, of course, he could calculate the mass of our globe.

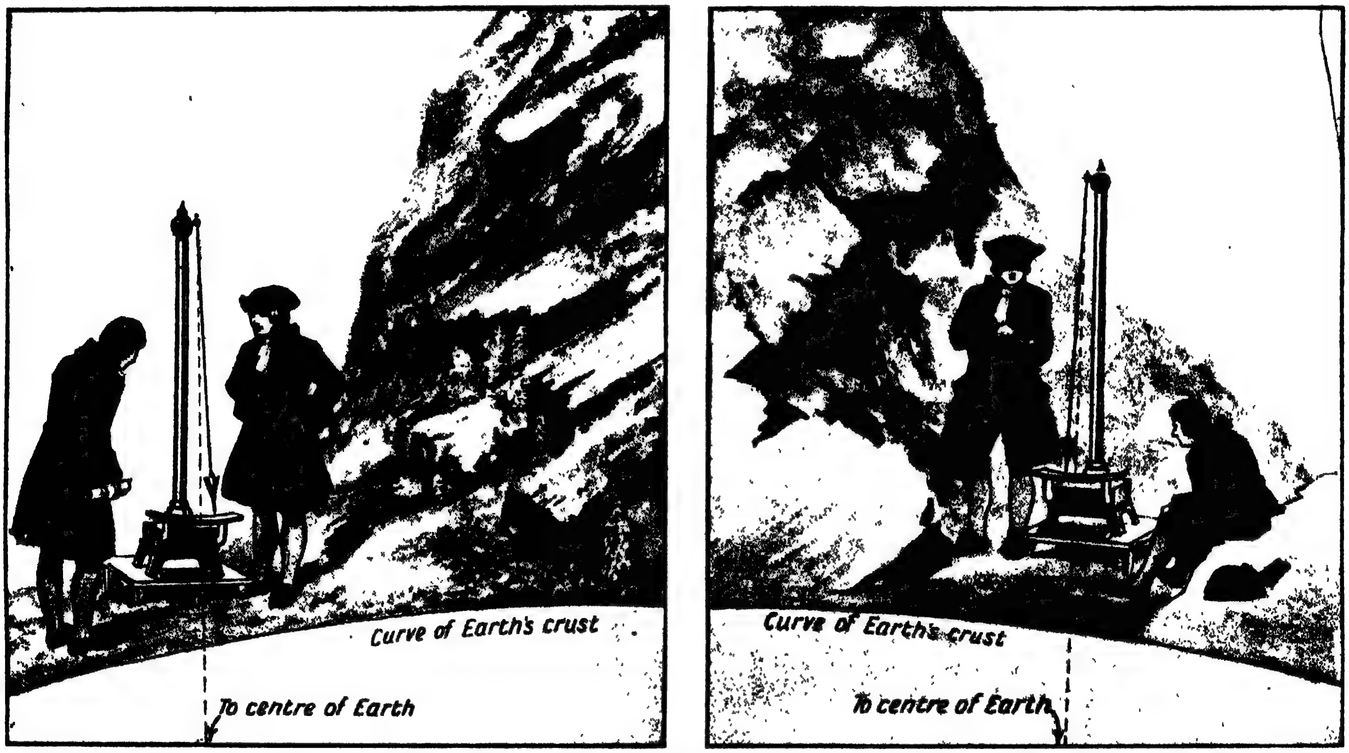
Still another method of weighing the Earth is by means of a pendulum. When we lift the bob of the pendulum and then release it, it swings down because the Earth attracts it. Of course the momentum it gets in the downward passage carries it up on the other side, but very soon it falls back again, and goes up on the opposite side; and so it swings to and fro, the reason being that the bob of the pendulum is constantly attracted by the Earth and tries to get as near the Earth's centre as possible.

The Behaviour of the Pendulum

If the pull on the bob is decreased the speed of the pendulum gets less, and by this means it is possible to measure the exact amount of decrease of the pull. For example, a pendulum that, swinging in London, makes 86,535 vibrations in a day, will make only 86,400 if swung at the Equator over the same period. The reason is that owing to the flattening of the Earth towards the Poles, London is a little nearer the centre of the Earth, where the pull of gravitation is concentrated, than a place on the Equator, and so the gravitation at London is a little more powerful than it is at the Equator. The pendulum is therefore retarded slightly at the Equator, because the pull upon the bob is less than it is in London.

An Astronomer in a Pit Shaft

Now this fact about the pendulum has been used for weighing the Earth, that is, for calculating its mass. A former Astronomer Royal, Sir George Airy, swung a very delicate pendulum at the mouth of a deep shaft, and calculated the number of vibrations in a given time. Then he took the pendulum to the bottom of the shaft, 1,200 feet below, and swung it in the same way. There the bob of the pendulum, being nearer the centre of the Earth, swung more rapidly, because the pull of gravitation was greater than at the top of the shaft. From the difference in the vibrations above and below the ground he was able to work out first of all the density of that part of the Earth's crust through which the pit was sunk, and then the density of the whole Earth. The



These pictures give a rough idea of the first attempt to discover the mass or weight of the Earth. A plumb-line was suspended on one side of a mountain, and the amount of deviation owing to the attraction of the mountain was measured. Then the plumb-line was taken to the other side of the mountain and the deviation in the opposite direction measured. From these facts the density of the mountain was worked out and scientists calculated how much more the Earth attracted the pendulum than did the mountain. Then they worked out the density of the Earth and, knowing its size, they could calculate its mass or weight

result was the same as in the other cases.

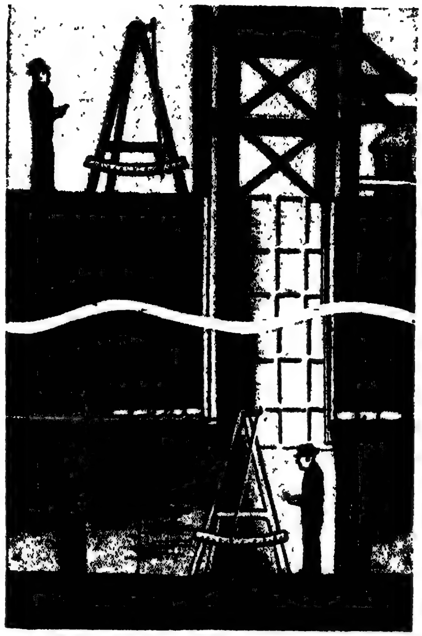
In more recent times yet another method of calculating the Earth's mass has been carried out in Germany. In 1879 Professor von Jolly, at Munich, suspended a curious balance from the top of a tower. From each end of a horizontal beam hung two pairs of scale pans, one pair being 69 feet below the other pair. In the upper pans were placed two glass globes filled with mercury or quicksilver, and in the lower pans two empty glass globes. At this stage the balance remained absolutely horizontal.

Mercury in the Balance

Then the professor transposed the full and empty globes on one side of the balance, that is, he put an empty glass globe in the top pan and the globe filled with mercury in the bottom pan. At once the horizontal beam tilted slightly on the side where the change had been made. This was due to the fact that the mass of quicksilver, being now nearer the Earth's centre, was attracted more than it had been when it was above, and it therefore tilted the beam. The amount of tilt was carefully measured.

Then a large leaden sphere was placed under the lower pan filled with mercury and the beam tilted still more. Again the deviation was recorded, and then from the figures thus obtained the density of the Earth could be worked out, and here the result was similar to that obtained by the other methods.

We may therefore be quite sure that the weight of the Earth, or its mass, is, as the men of science have worked out by so many methods, nearly six thousand million million million tons.



Another way in which the Earth's mass has been worked out is by noting the difference in the swing of a pendulum above and below a deep mine

The Romance of Mathematics

All this is a proof of what a wonderful and romantic science mathematics is Some people think it is a dry subject, but we have perhaps learnt more of the universe in which we live through mathematics than through any other science. It was, as we read in another part of this book, by means of mathematics that the two latest planets in the Solar System were discovered. Indeed almost all the sciences are dependent upon mathematices, and increasingly so as time goes on. This is particularly the case in such sciences as physics, astronomy, chemistry and mechanics. We must remember that the very earliest steam engines were the inventions of mathematicians.

THE SUN SEEN SHINING AT MIDNIGHT

Owing to the tilt of the Earth the Arctic regions in summer are turned towards the Sun, and the result is that as the Earth turns round on its axis no part of the Arctic regions is out of view of the Sun. Even at midnight the Sun can be seen shining in the sky. Daylight exists for the whole of the 24 hours. Tourists often go to North Cape in Norway to see the Midnight Sun. Of course, in winter the North Polar regions are turned away from the Sun, and then inside the Arctic circle they have the long Polar night, lasting for several months. But at that time the South Pole is turned towards the Sun, and then in the Antarctic circle the Sun can be seen at midnight

A GRANITE RAMPART SMASHED BY THE SEA

The power of the sea is beyond all belief, and nothing can in the long run withstand its destructive force. Breakwaters built by man have constantly to be repaired and renewed to prevent their being washed away. Here is a remarkable example of the power of the sea. The photograph was taken at Sennen Cove in Cornwall, and shows how the massive granite cliff, which seems so indestructible and impregnable, is being broken up by the great waves of the Atlantic Ocean. Some of these waves in an angry storm exert a force equal to nearly four tons on every square foot, and they can not only smash the rock but toss about blocks of stone and boulders weighing as much as thirty or forty tons. Everywhere, as it beats upon the shore, the sea is breaking up the rock. A shingly or sandy beach is a proof of how surely it can grind up even the hardest stone

WHAT WE OWE TO THE INCLINED PLANE

The inclined plane is one of the simple mechanical powers which man has discovered, and brought into everyday use, and very valuable it is in helping us to do all sorts of things that would be difficult or impossible without it. When we cannot lift a heavy load to a height, we can push or pull it up an inclined plane. The screw, without which all the complicated machinery of modern industry would be impossible, is only an inclined plane wound round a cylinder. Here we read many interesting things about the inclined plane

All our machinery, even the most complicated, is really a combination of a few very simple principles. We have already seen on Page 3 how the lever helps men to do things which, without its assistance, might seem quite impossible.

But the lever is not the only simple device which man has adopted and developed. Another of these is the inclined plane, and at first thought we might not regard that as a mechanical power or a simple machine at all. But without it we could not get on. It is as valuable as the lever and comes into almost every department of our lives.

Our very homes could not exist if it were not for the applications of the inclined plane. This mechanical power is found in the walls, doors, furniture, clocks, mangle, sewing machine, gramophone, and a hundred other devices which make life pleasant and comfortable. We shall see a little later on how it comes to pass that the inclined plane enters into these things

A Machine of Many Uses

An inclined plane is merely a slope, but whether it be a plank up which we roll a barrel, or a slanting road, it is nevertheless a machine, for it enables us to do what, without its aid, would be impossible or very difficult.

We cannot lift a heavy barrel four or five feet vertically to place it in a cart; but we can roll it up a plank without very much trouble. In doing this we have used an inclined plane as a machine to simplify our work.

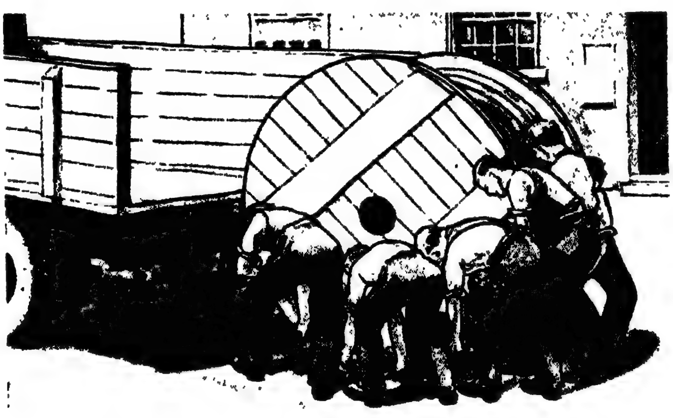
The idea of this device is very much the same as that of the lever. By means of a small force acting through a long distance the same amount of work can be done as by a large force acting through a short distance. To go back to the raised barrel in greater detail, we cannot lift a barrel weighing a hundredweight vertically to a height of five feet, but we can raise it easily to this height by pushing it up a sloping plank ten feet long. In the same way a horse can pull a heavily loaded cart up a slightly inclined road when it cannot possibly move the weight up a road inclined at 45 degrees.

It is by using this principle of the inclined plane that trains and motor-cars are able to travel to places high up on mountains. The road winds round and round or to and fro up the mountain side, and is really a very long inclined plane.

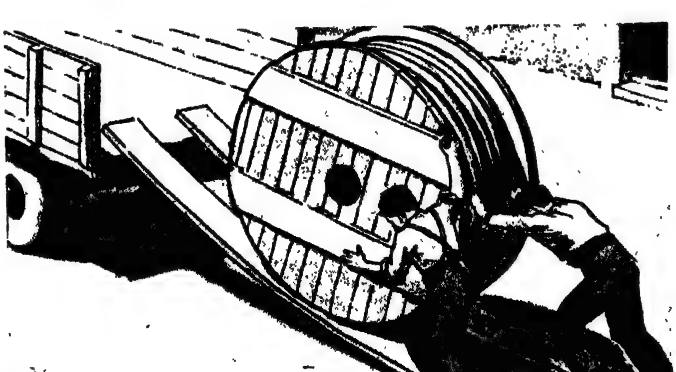
Let us see to what extent the inclined plane helps us to do work which without its help would be difficult and heavy. If we use a force which acts parallel to the inclined plane, we can support a weight as many times greater than that force as the length of the inclined plane is greater than its vertical height. Here is an example:

If a man wishes to lift a body weighing two hundredweights to a height of three feet, he would have to exert a force equal to two hundredweights if he lifted the weight vertically. But if he used an inclined plane twelve feet long, he would then require a force only three-twelfths of two hundredweights, that is, 56 pounds.

As we go about we constantly see the inclined plane being used in this way. Men load carts by its means, they let barrels or packages down into cellars easily by using the inclined plane, and they travel in hilly and mountainous districts with its help



All these men cannot lift this heavy cable drum into the lorry



With the aid of the inclined plane two men can now do what eight men could not do without its help

But they do more than this, they adapt the inclined plane in all sorts of ways. The wedge, for instance, for holding open a tree trunk while it is being sawn through, or for splitting a log, is really a double inclined plane. Another way in which the wedge is used is in launching a ship, wedges being driven under the keel.

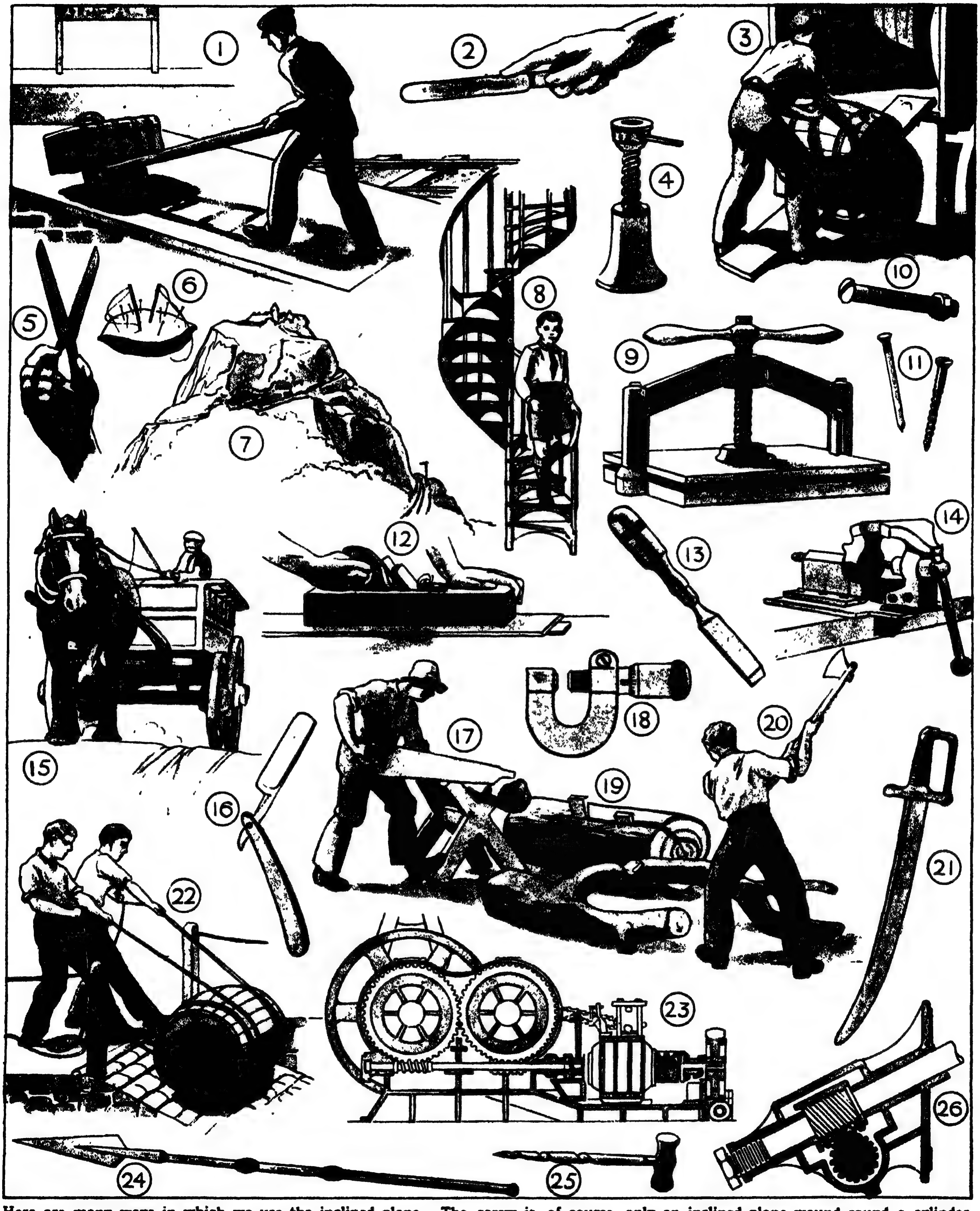
The Invaluable Wedge

But there is a still more familiar use of the wedge. Every one of us is using the wedge constantly. All cutting and piercing instruments, such as knives, razors, shears, scissors, scythes, sickles, axes, choppers, spades, spoons, pins, needles, nails, and such weapons as swords, bayonets, spears, lances and daggers are examples of the wedge, the angle being more or less acute according to the purpose for which the tool is required.

The very first wedges known were the front teeth of animals and men. Every time that we bite an apple or a piece of bread-and-butter we are using the lever of our jaw to drive home wedges, which are our teeth.

But a still more remarkable and useful application

WAYS IN WHICH WE USE THE INCLINED PLANE



Here are many ways in which we use the inclined plane. The screw is, of course, only an inclined plane wound round a cylinder. 1. Sloping railway platform. 2. Knife edge. 3. Loading plank. 4. Screw-jack. 5. Scissors. 6. Needles and pins. 7. Inclined mountain railway. 8. Spiral staircase. 9. Screw-turned press. 10. Bolt and nut. 11. Nail and wood-screw. 12. Plane blade. 13. Chisel edge. 14. Screw-vice. 15. Inclined roadway. 16. Razor edge. 17. Saw teeth. 18. Micrometer screw. 19. Wedges. 20. Axe blade 21. Sword blade. 22. Slope. 23. Worm gear elevator. 24. Spear-head. 25. Gimlet. 26. Worm gear for motor car

of the principle of the inclined plane is in the screw. This is simply an inclined plane wound spirally round a cylinder. Cut out a right-angled triangle in paper, with its shortest side two inches and the side that makes a right angle with the short side eight inches. Now roll this round a black-lead pencil, beginning with the short side and ending up at the point We shall have a representation of a screw.

The interval between successive threads of the screw is called its pitch, and the finer the pitch of the screw the less force will be required to make one turn, just as in the ordinary inclined plane the less the slope the less the force required to raise a body by its means.

The screw is used in a great variety of ways. We screw wood and metal together, we use the screw in a letter-press, in a vice, in an adaptable desk chair, in a jack-screw, and in scores of other tools and machines. In such devices as a press or a vice it is the inclined plane which moves as the screw is turned, but the principle is the same as when a barrel or a truck is wheeled up a stationary incline.

The screw is also used for measuring minute distances, as in the apparatus known as a micrometer-calliper. Let us understand the principle on which this works. Suppose a screw to have fifty threads in an inch; each revolution of the screw will advance its point through the fiftieth part of an inch. Now suppose the head of the screw to be a circle whose diameter is an inch; the circumference of the head would in that case be rather more than three inches. This can be easily divided into a hundred equal parts, which are distinctly visible.

Now, if a fixed scale be arranged against this graduated circumference the hundredth part of a revolution of the screw can be seen by noting the passage of one division of the head under the scale. As one entire revolution of the screw head moves the point through the fiftieth of an inch, it is clear that one division will correspond to the five-thousandth part of an inch.

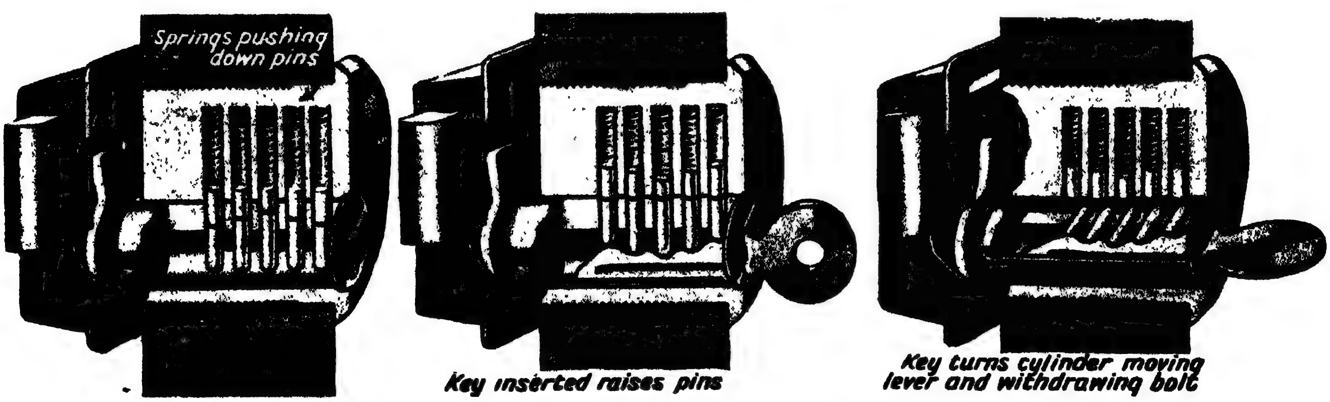
Another example of the use of the screw is in the worm gear where the thread of a screw acts in the teeth of a wheel.

Of course, it must be remembered that in the screw the friction is very great in proportion to the force applied, and this reduces to a large extent the amount of work which the screw theoretically does. On the other hand, it is the friction which makes the screw useful in holding boards together. If it were not for the friction the least shake would cause the screw to turn

A huge handpress at a London silversmith's, with its screw which is an adaptation of the inclined plane

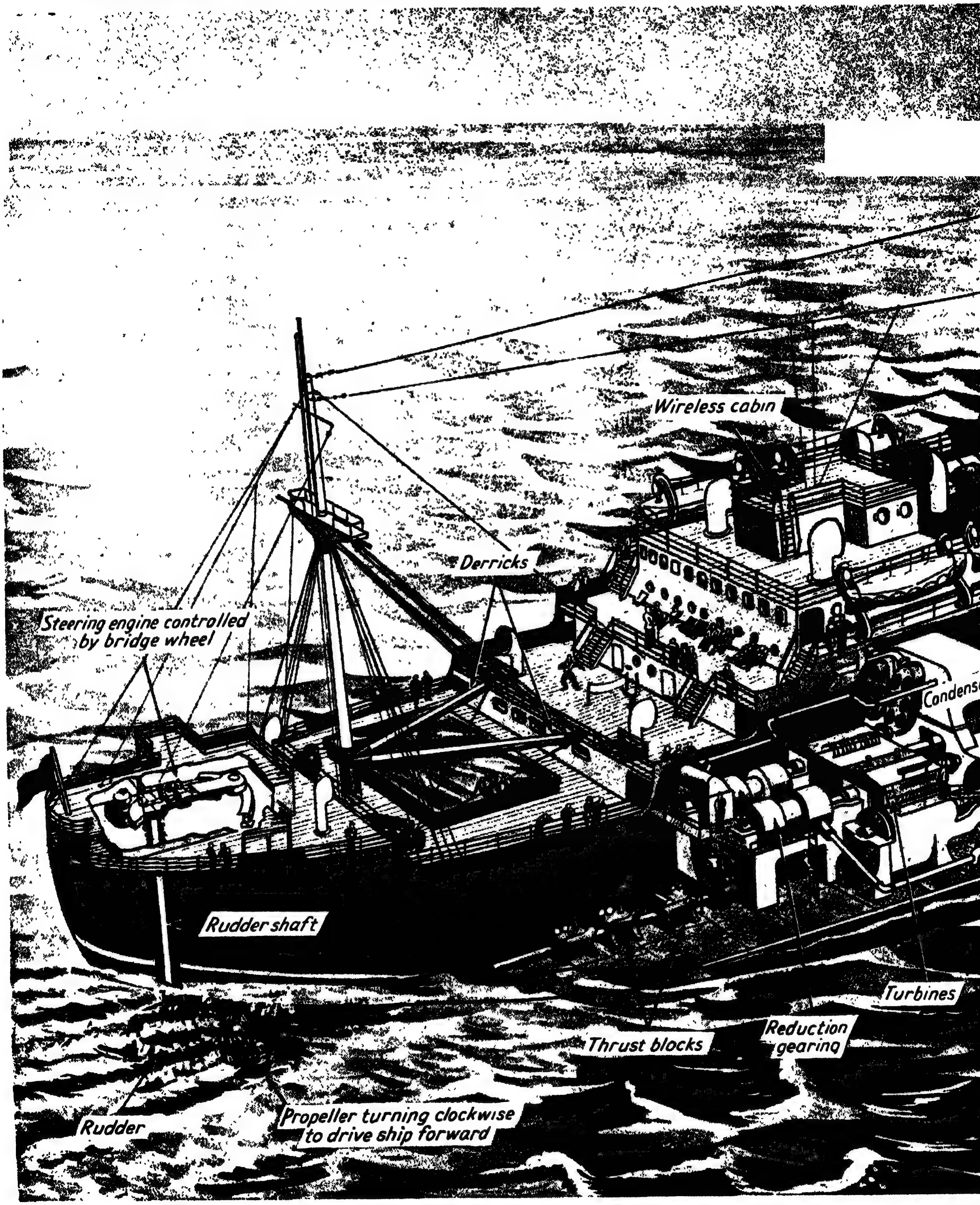
The slanting road of the St. Gothard Pass in the Alps, an inclined plane put to practical use

WHY THE LATCH-KEY OPENS THE STREET DOOR



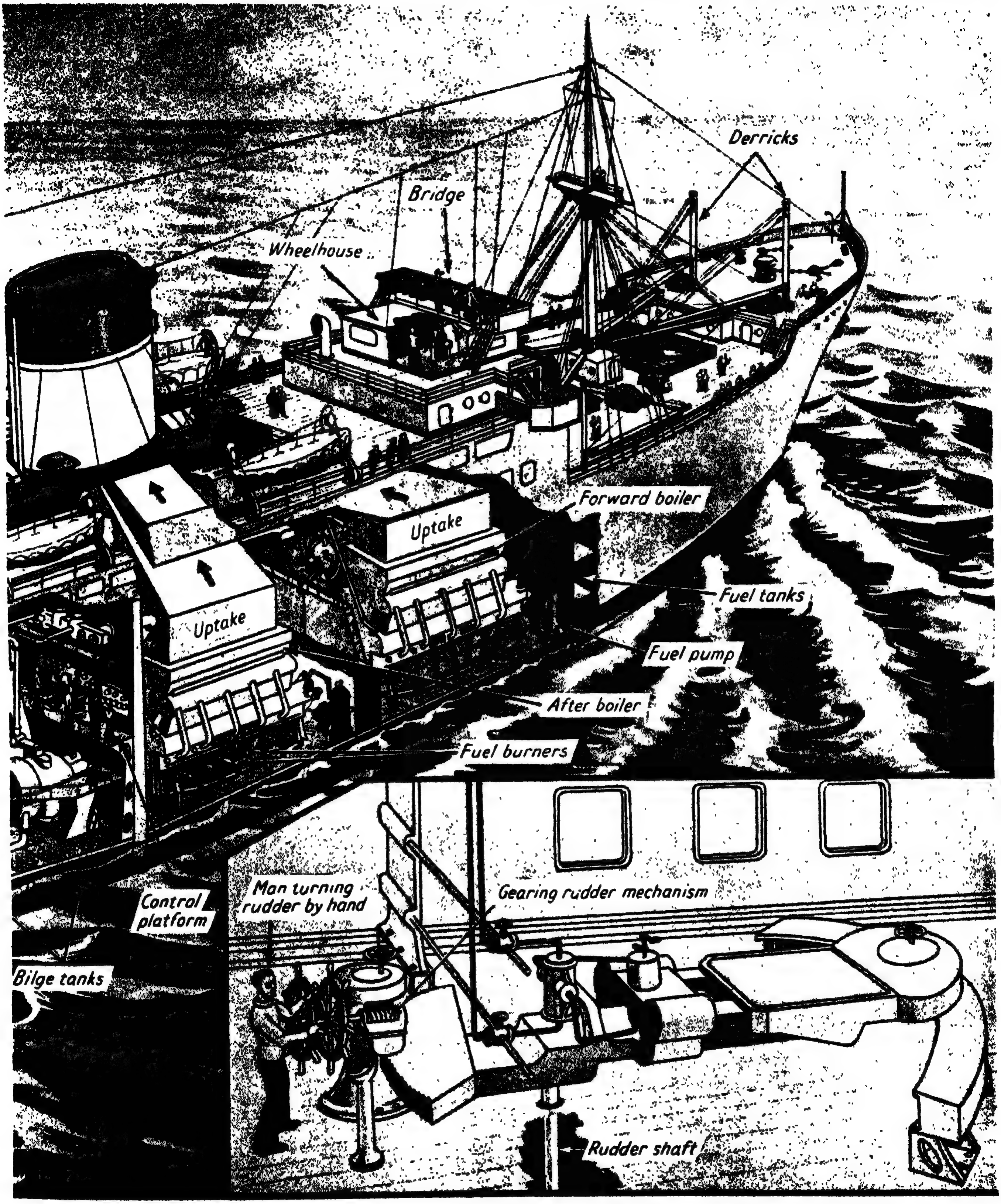
The Yale type of lock for a street door has a narrow cylinder revolving within a larger fixed cylinder. In the moving cylinder is a narrow twisted keyhole, and when the key is inserted a number of notches on it raise up pins in the lock until their tops are in a line. The first picture here shows the door locked, and in the second picture the key has been inserted, raising the pins. The key is now turned, and with the pins raised, is able to revolve the small cylinder, which turns back the bolt of the lock. Each lock of this kind has its own individual key to fit the pins. The key, being small and flat, is easy to carry in the pocket

INSIDE A TURBINE STEAMSHIP SHOWING



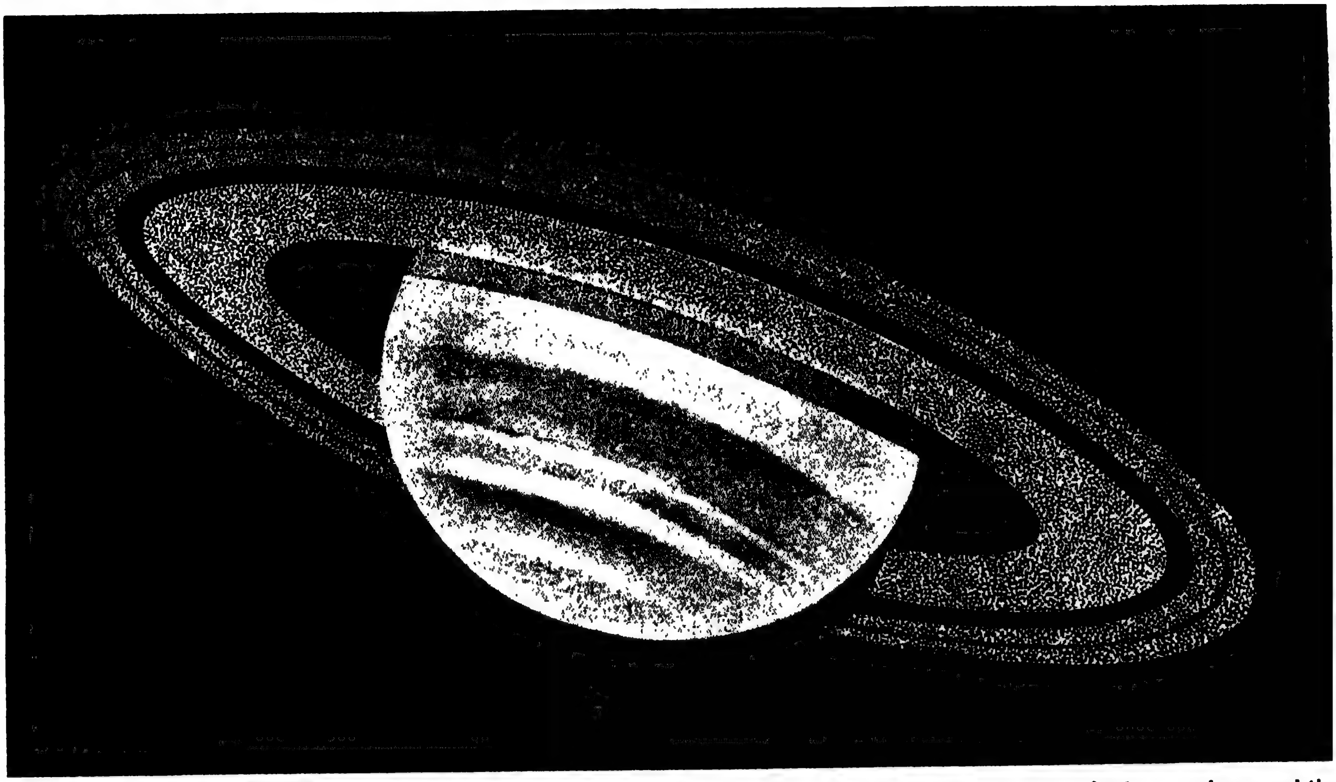
The drawing on these pages shows the inside of a medium-sized passenger and cargo liner. The ship is driven by two propellers turned by turbine engines taking steam from oil-fired boilers. Oil is pumped from the fuel tanks to the burners which turn the water into steam. Smoke and waste products from the burning oil are carried by uptake to the funnel. High pressure steam from the boiler passes to the turbines (explained on page 1221). After passing through the turbines the steam goes to a condenser, where it is turned into water again and fed back to the boilers. The turbines turn too quickly to drive the propellers safely, so the end of the shafts are connected to reduction gearing, which drives the propeller shafts, but at a lower speed. Thrust blocks through which the shafts pass

HOW IT IS PROPELLED AND STEERED AT SEA



keep the propeller shafts running true. On the bridge, the officer in charge signals to the engine-room control platform whether he wants the ship to go faster, slower, stop or reverse. The signals are reproduced on dials and the engineer then moves the levers controlling the engines. The ship is steered by the rudder, and the rudder shaft is connected to a half-circle gear, moving across a worm gear connected by rods and wheels to the wheel on the bridge. When the wheel is turned to the right, gears and valves allow some steam from the boiler to enter one of two pistons above the rudder. The piston is pushed forward and causes a cog wheel engaged with the half-circle gear wheel to move the rudder to the right. Admitting steam to the other piston turns the rudder in the opposite direction

SATURN AND HIS MILLIONS OF TINY MOONS



In this picture our scientific artist shows Saturn and his rings, which are made up of millions of tiny moons. As they revolve round the planet the outer part of each ring moves more slowly than the inner part, which could not be the case if the rings were solid. Saturn with his wonderful system of rings is the most surprising body in the whole of the heavens. Astronomers believe that the rings once formed part of a large moon and that this, getting too near the planet, was torn to pieces, and the fragments then circled round Saturn just as the Sun's planets circle round him. One day our own Moon may be drawn so close to the Earth that it will meet the same fate

How Saturn's rings would appear to us if we could stand on the planet in a high latitude, such as the position the British Isles occupy on the Earth. The rings would look like a giant luminous arch stretching across the heavens and on it would be projected the shadow of the planet itself, which in a high latitude would take a conical form, as shown in this picture. The figures of the children placed on the planet are, of course, fanciful, for it is quite unlikely that any life, as we understand the term, can exist on such a world. What we see when we look at Saturn is probably not the planet's surface but an envelope of cloud which encircles it

A WORLD WITH A BILLION MOONS

As we look up into the sky there is a certain similarity about the various heavenly bodies. They are all round, and they shine or twinkle, although of course there is an enormous variation in their sizes and their temperatures. But there is one body, the planet Saturn, which is quite different from all others. It is one of the Sun's family of worlds, but it differs from the others in having a series of gigantic rings whirling round it. It is in some ways the greatest wonder of the heavens, and here we learn something about it

As we look up into the sky at certain times of the year we see what appears to be a large, rather dull star with nothing particular to distinguish it from the other heavenly bodies. But astronomers will tell us that this is the planet Saturn, and if we can get them to allow us to look at it through a large telescope we shall see a most remarkable sight. Instead of the ordinary round globe which is the appearance of other planets, we shall see a rather flattened globe, much flatter in shape than the Earth, with a series of huge flat rings round it.

As we look at Saturn it does not always present the same appearance, for sometimes we are looking down at the rings, sometimes up at them, and sometimes we see them edgeways. It is a strange fact that while these rings are very wide—their total breadth is about 42,000 miles—they are very thin, probably less than 100 miles. Indeed, they are something like a ring of notepaper put round a large orange.

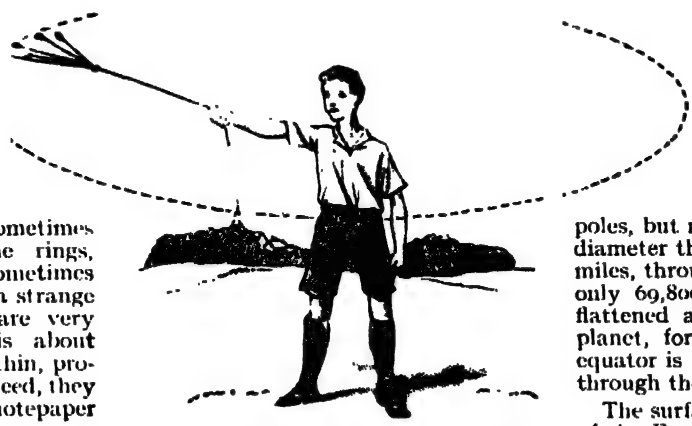
Saturn has been noticed from very ancient times, but nothing was known of his rings till Galileo turned his telescope on the planet in 1610 and saw something which puzzled him. "It appears triple to me," he wrote; "the largest star stands in the centre, the other two lie on a level, one east, the other west, and appear to touch the centre star. They seem like two servants assisting old Saturn to complete his journey, and do not budge."

A Perplexed Astronomer

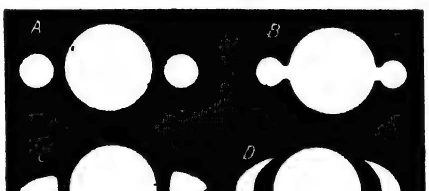
But they did budge, for Galileo found that after becoming smaller, in two years they had disappeared altogether. He was very upset at this, and could not understand it at all. "I do not know what to say in a case so surprising, so unlooked-for, and so novel," he wrote. "The shortness of the time, the weakness of my understanding, and the fear of being mistaken, have greatly confounded me."

But the great man was not mistaken. The strange additions to the planet reappeared later, and though at first they were supposed to be attendant moons, and even handles attached to the planet, their true nature was discovered in 1656 by a great Dutch astronomer, Christian Huygens. It was such an extraordinary discovery that Huygens felt he dared not announce it at once, so he recorded his discovery in the strangest way any scientific fact has ever been set down. He wrote it thus: aaaaaaa ccccc d eeeee g h-iiiiiii llll mm nnnnnnnnn oooo pp q rr s ttttt uuuuu. This was really a cryptogram in which lay hidden the Latin words:

Annulo cingitur, tenui, plano, nusquam cohaerente, ad eclipticam inclinato, which means, "He is surrounded by a thin, flat ring nowhere touching him and inclined to the ecliptic."



How Saturn's Rings revolve. The boy represents the planet, the balls the rings, and the string the planet's pull or gravitation force, which prevents the rings flying off into space



Saturn as seen by old astronomers. A. Galileo, 1610; B. Scheiner, 1614; C. Riccioli, 1640; D. Hevelius, 1688; E. Riccioli, 1650; F. Eustachius de Divinis, 1664

The ecliptic is a great circle which forms the apparent path of the Sun, but is really the path which the Earth in its orbit would seem to follow if it were seen by an eye placed on the Sun.

Many other astronomers have studied Saturn and his rings, and the more we know about this planet the more wonderful he seems. He revolves at the average distance of 886 million miles from the Sun. When he is farthest from the Sun he is 1,028 million miles away, but when he is nearest he is only 774 million miles distant. It is clear, therefore, that his orbit or path is not a circle, but an ellipse.

The planet, like the Earth, is flattened at the poles, but much more so, for while the diameter through his equator is 76,500 miles, through the poles the distance is only 69,800. Indeed, Saturn is more flattened at the poles than any other planet, for the diameter through the equator is one-tenth greater than that through the poles.

The surface of Saturn is 86 times that of the Earth, and the space he fills 800 times as great. But in proportion to his size he weighs much less than the Earth. It is true that his mass or weight is 95 times that of the Earth, but if he were the same size as our world he would weigh only one-eighth as much. In fact Saturn weighs about the same as a globe of walnut wood of the same size, and if he were placed in a huge bowl of water he would float with one quarter of his bulk above the surface. Indeed, the matter of which Saturn is made is the least dense of all planets.

Saturn's Long Journey

He turns round on his axis once in every ten hours, and he goes round the Sun in 29½ years, at the rate of 6 miles per second.

Of course Saturn's distance from the Earth varies enormously, and as a result in the course of 15 years he gains or loses nearly 50 per cent. of his brightness as seen by us. When nearest to the Earth he is the same size as a sixpenny piece held up before us at a distance of 210 yards.

Saturn shines by reflecting the light which he receives from the Sun, but the light and heat which he receives is only one ninetieth of that which the Earth receives. He has not cooled down as

much as the Earth and is probably exceedingly hot. We see belts around him, and these are believed to be due to clouds on his surface. What we see is not the real surface of Saturn, but his cloud-laden atmosphere.

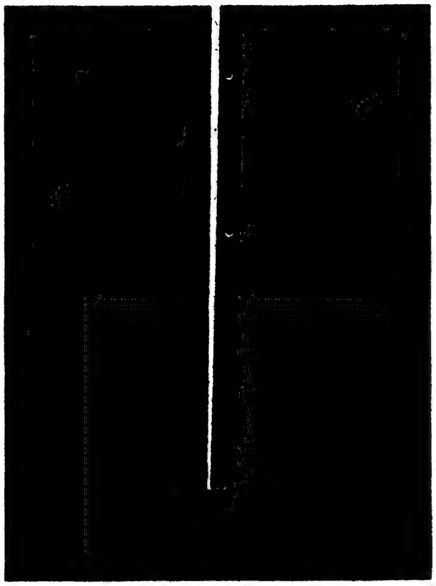
Saturn has nine moons, and some astronomers think there is a tenth. Many of these have been discovered in the present century. The one farthest away from Saturn is called Phoebe, and it is about 8,000,000 miles from him. Another moon, Iapetus, is at a distance of 2,225,000 miles. The largest moon is Titan, 2,720 miles in diameter, or a little bigger than our moon, and it circles round Saturn at a distance of 770,000 miles.

The Marvel of the Rings

But the great wonder of this planet is, of course its rings. It was at first thought that these were made of solid matter, but some scientists believed they might be liquid. Students of mathematics, however, worked out sums which showed that they could not be continuously either solid or liquid, for the enormous strain upon them as they whirled round the planet would tear them to pieces.

It is now agreed that they are made up of millions of tiny moons, "pocket moons" or "moonlets," as someone has called them. Apart from the calculations of the students of mathematics, we finally a semi-transparent ring 11,000 miles wide, with a clear space of from 7,000 to 8,000 miles between the inner edge of the ring and the planet itself.

Speaking of these rings, Sir James Jeans says: "We find one-way traffic, with the slower traffic keeping to the outside."



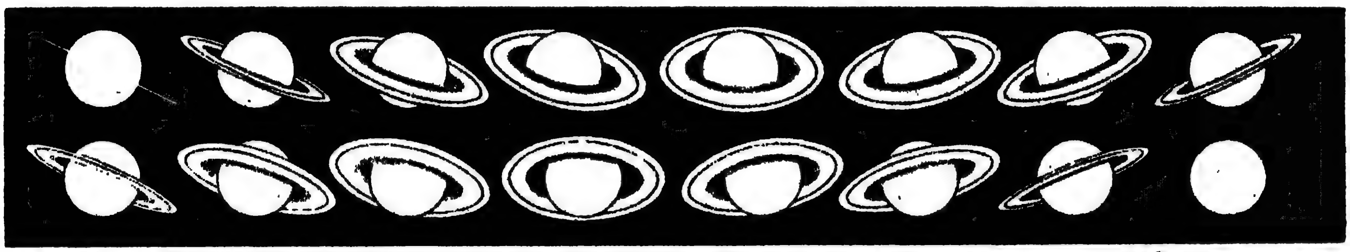
Saturn's rings as they would be seen by anyone standing on his equator

During a Saturnian year, that is in 29½ of our years, the rings are twice turned edgewise and twice opened out to their widest extent as seen from the Earth. When quite edgewise they almost disappear from view, and astronomers in early days who saw them like this thought the planet had a bar thrust through from side to side.

How were the rings formed? Well, it is generally believed that they once formed part of a large moon, and that this, getting too near to Saturn, was torn to pieces, and the fragments then circled round the planet just as the Sun's planets circle round him. Sir James Jeans thinks that one day our own moon will be drawn so close to the Earth that it will meet the same fate, when the Earth will no longer have a moon, but will be surrounded by rings like Saturn. That event, however, lies a long way off in the future.

The Earth without a Moon

When it happens, if it ever does, the effect will be very strange. The Earth will no longer have a Moon, but the nights will be lighter than they are now, for the rings will reflect a great deal more of the Sun's light than the present Moon does, and there will be moonlight all night long, for the rings will surround the Earth in all parts. At present, of course, the Moon is sometimes on the daylight side of the Earth, so that the night side gets no reflected light from it.

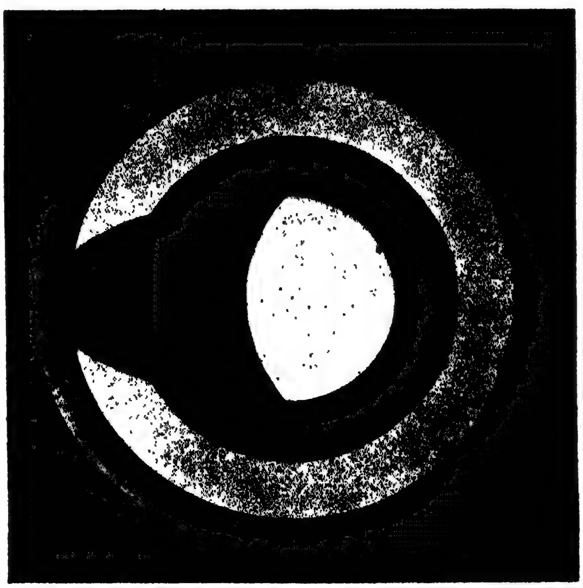


Saturn and his rings as they appear from the Earth at different periods of his revolution round the Sun

know this must be so, because that wonderful instrument the spectroscope, of which we read in another part of this book, has shown that the outside of the rings moves more slowly than the inside. Of course that could not be if the rings were a continuous sheet.

It is a marvellous idea, to think of this giant world with a billion or more tiny moons circling round so close together that they look like rings. Saturn's rings are certainly, as the great Cambridge scientist Clerk Maxwell said, the most remarkable bodies in the heavens.

There are three of these thin, flat rings, an outer bright one 12,000 miles wide, then a space known as Cassini's Division, after its discoverer, which is 1,800 miles wide, then another ring, the broadest and brightest of the set, 17,000 miles wide, and

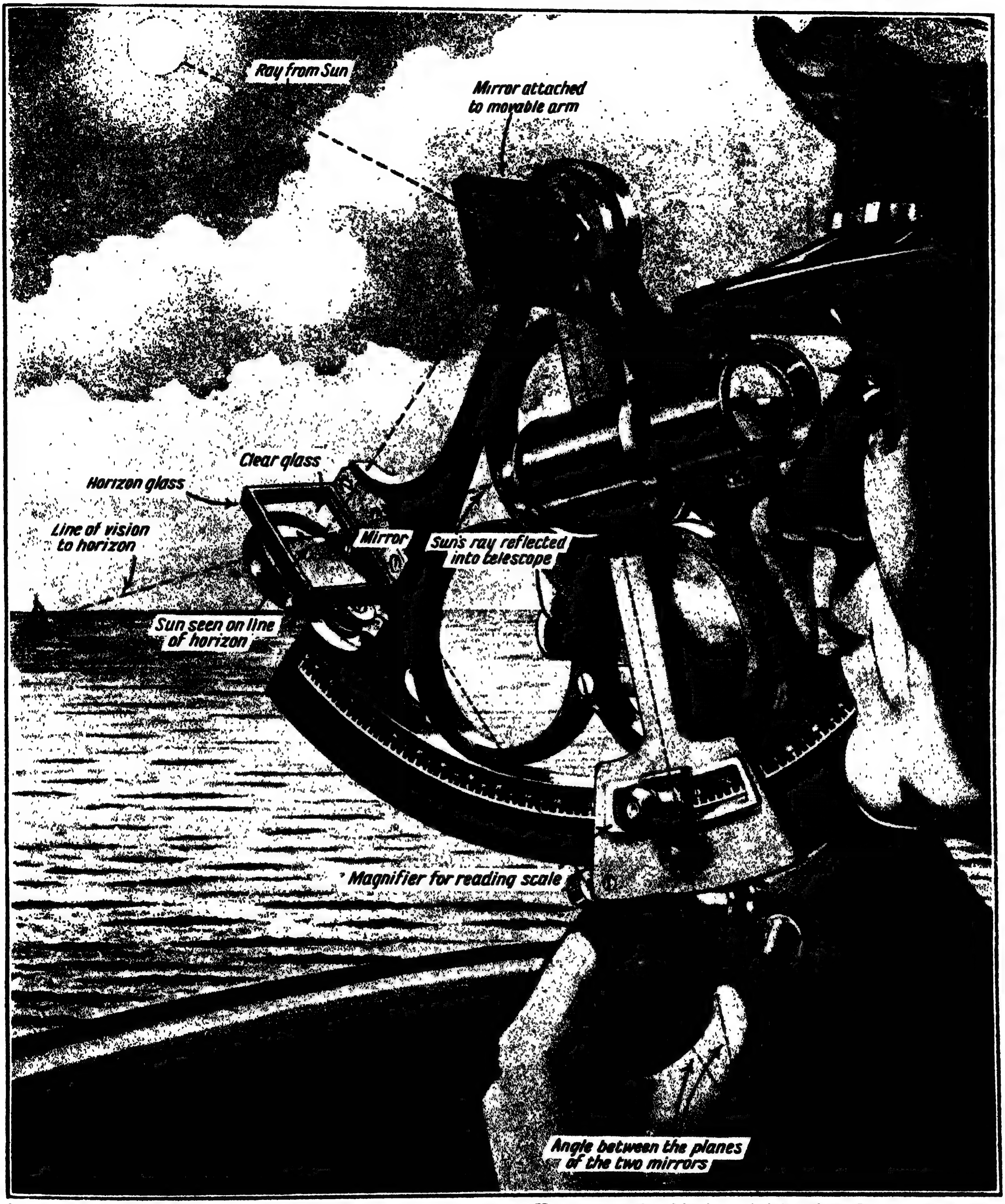


Saturn and his rings with the shadow cast by the planet as they would appear looking down from above

Clerk Maxwell used to describe the rings of Saturn as a shower of brickbats, among which there would inevitably be continual collisions. The result would be that the rings—would spread farther inwards and outwards. In the course of time the outward spreading would carry some of the moonlets so far that they would slowly come together and form one moon. Those that spread inwards would at last reach the atmosphere of the planet, become white hot, and disappear, just as meteorites do when they come into the Earth's atmosphere.

As a matter of fact, it is generally believed that the rings have changed in width since they were first seen and studied. But we cannot be quite certain of this till the rings have been studied very much longer.

A CAPTAIN FINDS HIS WAY BY THE SUN



A captain finds his position at sea by means of a sextant, shown here. He measures the altitude, or height, of the Sun or a star above the horizon, and then noting Greenwich mean time, from his chronometer, checked by wireless signal, makes certain calculations, and discovers his latitude and longitude. This is how he takes the altitude. He looks through the telescope at the horizon, so that a line from his eye to the horizon just touches the top of the mirror on the horizon glass. He then moves the arm of the sextant till the mirror at the top is in such a position that the image of the Sun in it is reflected upon the line on the horizon glass. The captain next reads the scale through the magnifier, gets the angle between the two mirrors and multiplies it by two, which gives him the altitude of the Sun. Next to the compass, the sextant is the most important instrument a ship carries

MARVELS THE EYE OF THE CAMERA SEES

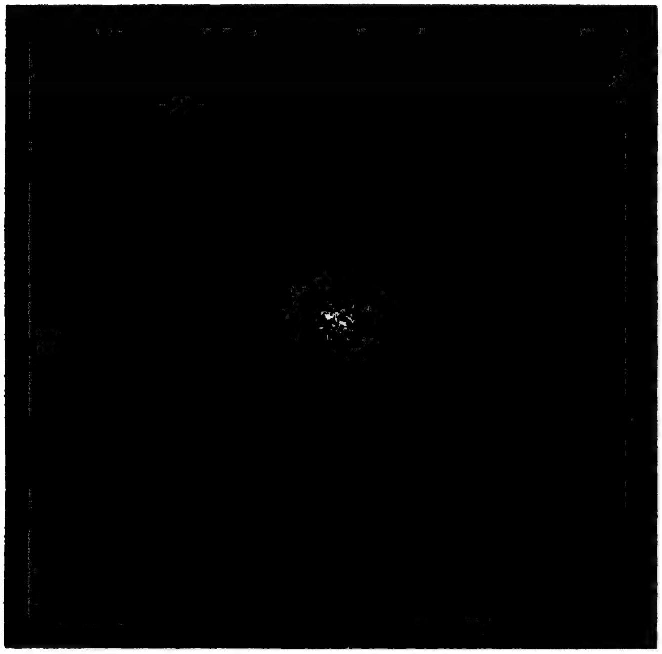
To get a true knowledge of the heavens and the myriads of stars that have been recorded there, we need something more than the big telescope. Without that, of course, we could never see the millions of stars that exist. But even with a big telescope the human eye cannot discern more than a certain number of stars. It is the partnership of the telescope and the modern camera with its very sensitive plates that gives us the wonderful knowledge of the distant heavens that we have.

By increasing the time of exposure, smaller and smaller stars are continually being recorded on the photographic plates, and indeed with a really big telescope and an up-to-date camera there would appear to be no limit to the faintness of the stars that can be photographed provided increasingly sensitive plates can be produced. Both the telescopes and the cameras are becoming more and more efficient. Already there is a 100-inch reflector telescope at Mount Wilson Observatory in America, and many of the fine star photographs taken by means of that telescope appear in this book.

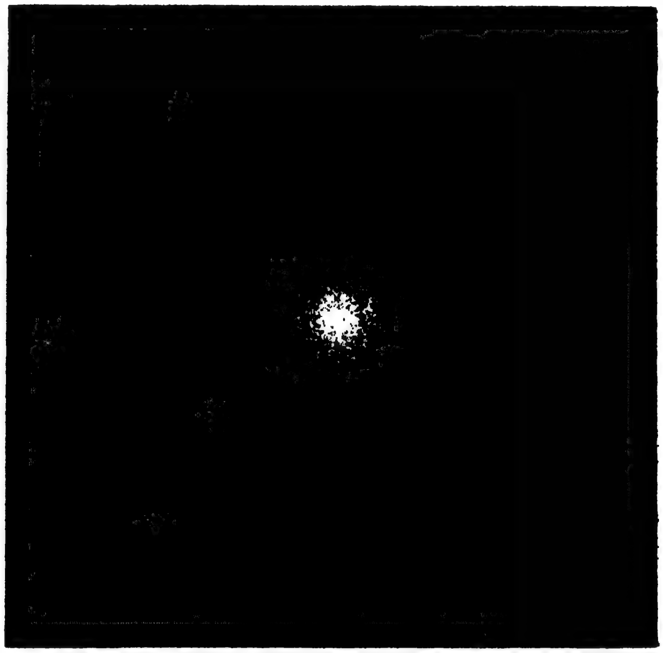
But that telescope will soon be outclassed, for already a 200-inch telescope is being made. All over the world astronomers are busily engaged in photographing the whole of the heavens, and in a few years there will be a complete chart of all the stars down to the fourteenth magnitude, accurate as to position and brightness.

The penetrating keenness of the camera's sight, far exceeding that of any human eye, can be understood from the four photographs on this page, which are published by courtesy of the Mount Wilson Observatory in California. They were taken with the 60-inch reflector telescope. Each extended exposure brings in stars of one more magnitude than the previous exposure.

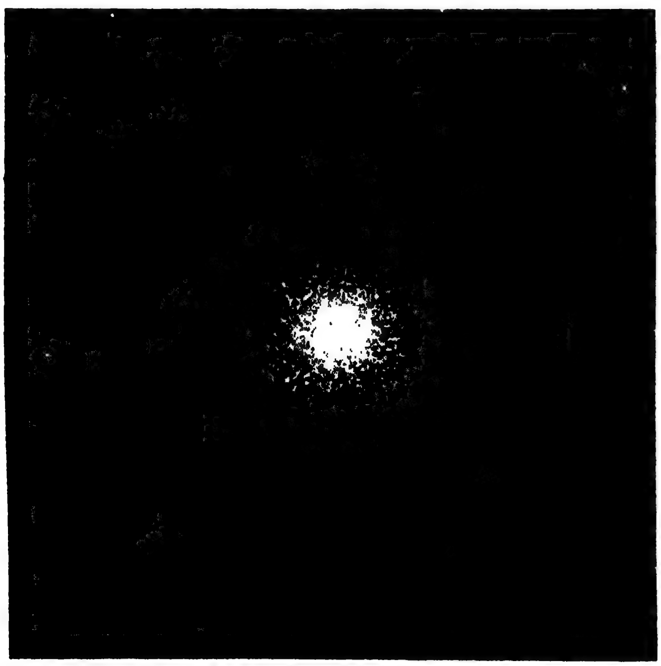
As the Earth turns round on its axis, the heavens appear to be moving round, and therefore exceedingly accurate and complicated clockwork has to be linked with the telescope to move it round.



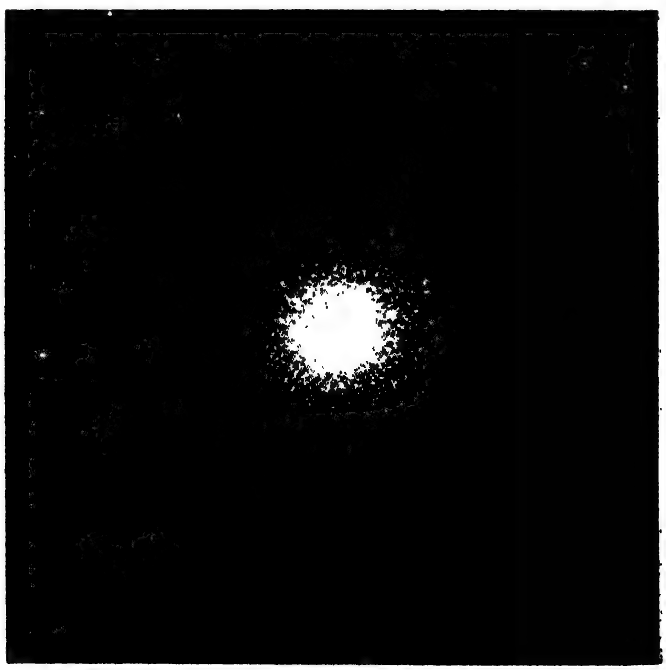
Star Cluster in Hercules after 6 minutes' exposure



The same Cluster after an exposure of 15 minutes



The Star Cluster as it appeared after 37½ minutes



What the plate showed after 94 minutes' exposure

THE CAT AND ITS NINE LIVES

The cat has been the friend of man for thousands of years. It was probably first tamed in Africa, and the Ancient Egyptians used its services as we do those of a sporting dog, to retrieve birds caught in the chase. Probably the Egyptian cats had less dislike of water than have our modern cats, for the fact that cats nowadays do not often care to wet their feet is due to the comfortable and easy lives they live. Domesticated ducks sometimes show a distaste for getting wet. Many interesting facts about the cat are given here.

WILD cats, looking remarkably like the pets of our hearthrugs, are still found in the remoter parts of Scotland, but strange to say our domestic cats are not descended from the European wild cat but from the wild cat of Africa, an animal widely spread over that continent. Of course, there has probably been some crossing of the two species, but scientists are now agreed that our domestic cat is a descendant of the African cat.

At a very early period in history, the Egyptians tamed the wild cat, and we know from an old Egyptian wall painting, now in the British Museum, that they used the cat as we do the dog when they went bird-hunting. The picture shows the cat with the family of its owner among the reed-beds of the Nile, retrieving birds that have been brought down by arrows or throwing sticks. The cat is seen with one bird in its mouth, another held by its fore paws, and a third between its hind paws.

The Cat Defends the Corn

When Egypt was the granary of the ancient world, the cat was, of course, a very important animal to the inhabitants of that land, for it was essential to keep down the numbers of rats and mice that proved such pests in devouring the corn, and the cat has always been the best friend of man in this work.

It is perhaps not surprising that the animal came to be greatly honoured and revered in ancient Egypt, till at last it was regarded as a sacred beast; and among the tombs of Egypt many mummies of cats that had been carefully embalmed before burial have been found.

The cat still goes on with its work of catching mice, and it has thus remained one of the greatest friends of man. There are few houses, indeed, in Great Britain where a cat is not kept.

The cat is a very interesting animal. It varies from that other domestic pet, the dog, in many ways. Its teeth are much more pointed than the dog's and its claws are far sharper than a dog's claws. These can, however, be drawn back when not wanted, and the cat's foot then becomes a beautifully soft pad on which it walks with ease and silence. A dog cannot draw back its claws. Of course, in the case of the cat the claws are its chief weapon, whereas in the dog the really formidable weapons are the teeth.

How a cat falls on its feet

There is a great difference, too, between the eyes of the cat and those of the dog. Both have large pupils when the light is dull, the pupil, of course, being the dark part in the centre of the eye, but when there is a strong light the dog's pupil contracts to a small disc, while the cat's changes to a narrow slit. Indeed, when the light is very bright the pupil is nothing more than a thin, vertical line. It is a wonderful case of adaptability, and the same thing is found in our own eyes, though not to an equal extent.

The pupil is really the opening in the iris which admits the light to the retina or curtain at the back. As in the case of the photographic camera, if the light is very weak the opening must be enlarged to admit as much of the light as possible, otherwise no image would be thrown on the retina. The pupil, therefore, acts like the various stops of the camera, but, unlike the camera, it does not have to be worked from outside, its operation is purely automatic.

Sharp Eyes and Ears

It is very interesting to watch the changes in the pupil of the cat's eye as the light varies. Of course, the old saying that a cat can see in the dark is nonsense. No animal can see in absolute darkness, for the simple reason that seeing is the result of light, and when there is no light at all, which is very rarely the case, no animal can see.

But a cat probably sees better than we do in a bad light, because its pupil opens wider so as to let in every bit of light there may be, however faint. The cat's pupil will also expand under the influence of excitement, opening widely if, for example, we put a mouse-trap containing a mouse on the floor before it. The pupils also expand under the influence of fear; as when a dog goes up to a cat and barks at it.

The hearing of the cat is perhaps more acute than its sight. Even when a brick wall intervenes between two gardens, a cat in one garden can hear the gentle footfall of a mate walking in the other garden, a sound which no human ear could possibly detect.

The cat's sense of smell, however, is much less than the dog's. A naturalist, Mr. Arthur Nicols, carried out an interesting experiment which proved this.

"I have long had reason to think," he says, "that the sense of smell in cats is much less highly developed than in dogs and even among other animals,

A cat is a very sure-footed animal and can easily walk the tight-rope

because among other things we see the difficulty cats often seem to experience in finding food thrown down to them unless they see it fall, bobbing their noses about on the floor in search of it, even when it is no distance from them.

When Dog Beats Cat

"A few days ago, therefore, I prepared some dozen or so of dainty pieces of meat, both raw and cooked, and some pieces of fried cod and herring, and taking my dog into a room from which every ray of light had been excluded, threw pieces of the meat into different parts of the room. As might have been expected, each piece was found by him almost as soon as the first could be eaten.

"The house cat was afterwards tried in the same room and had great difficulty in finding pieces dropped close to her, failing altogether in securing some of them. What the dog accomplished in the space of a moment, the cat could not do in a quarter of an hour, for on letting light into the room I found pieces of the fish lying about in the farther corners.

"There was no comparison between the one and the other in the manner of searching for the food. The dog went to work with confidence and after a few seconds employed in sniffing round, could be heard eating until every piece of meat had been found. The cat, on the contrary, walked about mewing, and seemed to have no idea of the presence of the fish until she was close to it.

"The cat was quite familiar to me, and had been kept quite a long time without food intentionally. I used fish because it was a food to which she was accustomed and calculated to emit sufficient smell. The result impressed me with the conviction that cats discover food by smell with very indifferent success, whence perhaps it may be inferred that their perceptions generally through this sense are more feeble than those of some animals."

Later experiments with other cats and dogs gave the same result.

The Warning Whiskers

In addition to its eyes, ears, and nose, the cat has still another means of finding its way and avoiding difficulties when pursuing prey or travelling in the dark. The front part of its face is provided with long, sensitive whiskers and when it is creeping along these touch any obstacles there may be, and warn the cat to be careful. They also enable the cat when pursuing prey, such as a bird or mouse in the garden, to keep its eyes on the victim and go forward without watching the path. The sensitive whiskers enable

The cat's pupils closed to a slit in a bright light

The cat's pupils opened wide in a dim light

THE MARVELLOUS TONGUE OF THE CAT

At some time or other a cat has probably licked our hand, and we know how very rough its tongue feels. This picture shows part of a cat's tongue magnified about fifty times. As we can see, it is covered all over with hard points of flesh rising above the surface of the softer flesh. These are all directed backwards, so that when the cat licks itself, as it so often does, the tongue acts as a comb and smooths the fur. But the rough tongue with its backward points serves a more useful purpose even than this. The cat's teeth are not so sharp as the dog's, and are therefore not so capable of gnawing flesh or bones. It is with its tongue that the cat scrapes a bone so clean and licks a plate, in which its food has been placed, much cleaner than a dog. Its tongue is a wonderful and important organ. It is well supplied with muscles which enable it to shorten, lengthen, and twist in all directions. The tip can be formed into a kind of spoon which enables the cat to lap up milk. It also acts as a kind of hand in the mouth, directing the movements of the food

it to avoid obstacles on the way, for they are provided with special nerves and act as delicate organs of perception.

If we touch a cat's tongue we find that it is very rough, and seen through the microscope it has a most extraordinary appearance, showing many small points directed backwards. These help the cat to lick the flesh from bones, and also serve as a comb when the cat is at its toilet. Cats are very particular about cleanliness, and are always washing and combing their fur with their tongues.

Another interesting thing about the cat is that it is very sure-footed, and is rarely hurt by a fall.

We have probably been astonished to see a cat fall from a great height and alight on its feet without any apparent injury or inconvenience. We can understand then that a cat is reputed to have nine lives.

Why is it that a cat can fall from such a great height without hurting itself? If we see a cat fall from an upper window, or some similar situation, we shall notice that even when it begins with its back towards the ground or head downwards it invariably rights itself during its journey through the air, so that the feet are in the proper position for alighting when it reaches the ground.

We know exactly how this manoeuvre is performed from slow-motion films, which have been taken of falling cats starting from different positions. The brain of the animal when it begins to fall realises instantly that its position is incorrect, and messages are at once flashed to the limbs and other parts of the body to right themselves so that the head may be in the correct place relative to the rest of the body and to the pull of gravity.

The cat has learnt this method of self-preservation in the course of ages, because it has needed it. It walks in perilous places and is liable to dangerous falls, so that if its body did not automatically adjust itself in coming down so many cats would have been killed that the race might have been in danger of becoming extinct.

Human beings have not acquired this faculty to the same extent because they have not needed it in the same way. The average human being rarely walks in a position where a fall would be serious. If, however, he does fall from a height as proportionate for his size as the fall of a cat for its size, he is usually killed or seriously injured.

POP-GUNS AND CATAPULTS AMONG THE PLANTS

If plant species are to be saved from extinction they must find some way of distributing their seeds, so that the race may be carried on in suitable soil where new plants can grow and thrive and in their turn produce seed.

It is quite clear that if all the seeds produced by a plant were simply to fall down round the parent plant the ground would be cumbered with little seedlings that would choke one another. In self-defence, therefore, plants must distribute the seeds.

Different plants have developed different ways of dispersing their seeds. Some allow the wind to carry them to a distance from their parent plant, as we see on page **10**, others are carried by water, and others by animals and birds; while others have evolved a mechanism for firing or catapulting the seed or spore to a considerable distance.

In certain cases the fruit producing the seed becomes a kind of popgun, tissues under great tension being suddenly released and firing the seed from a hole or opening as in the case of the squirting cucumber. In other cases part of the fruit under tension being released curls up suddenly and acts as a sling, hurling the seed to a considerable distance, where it can germinate

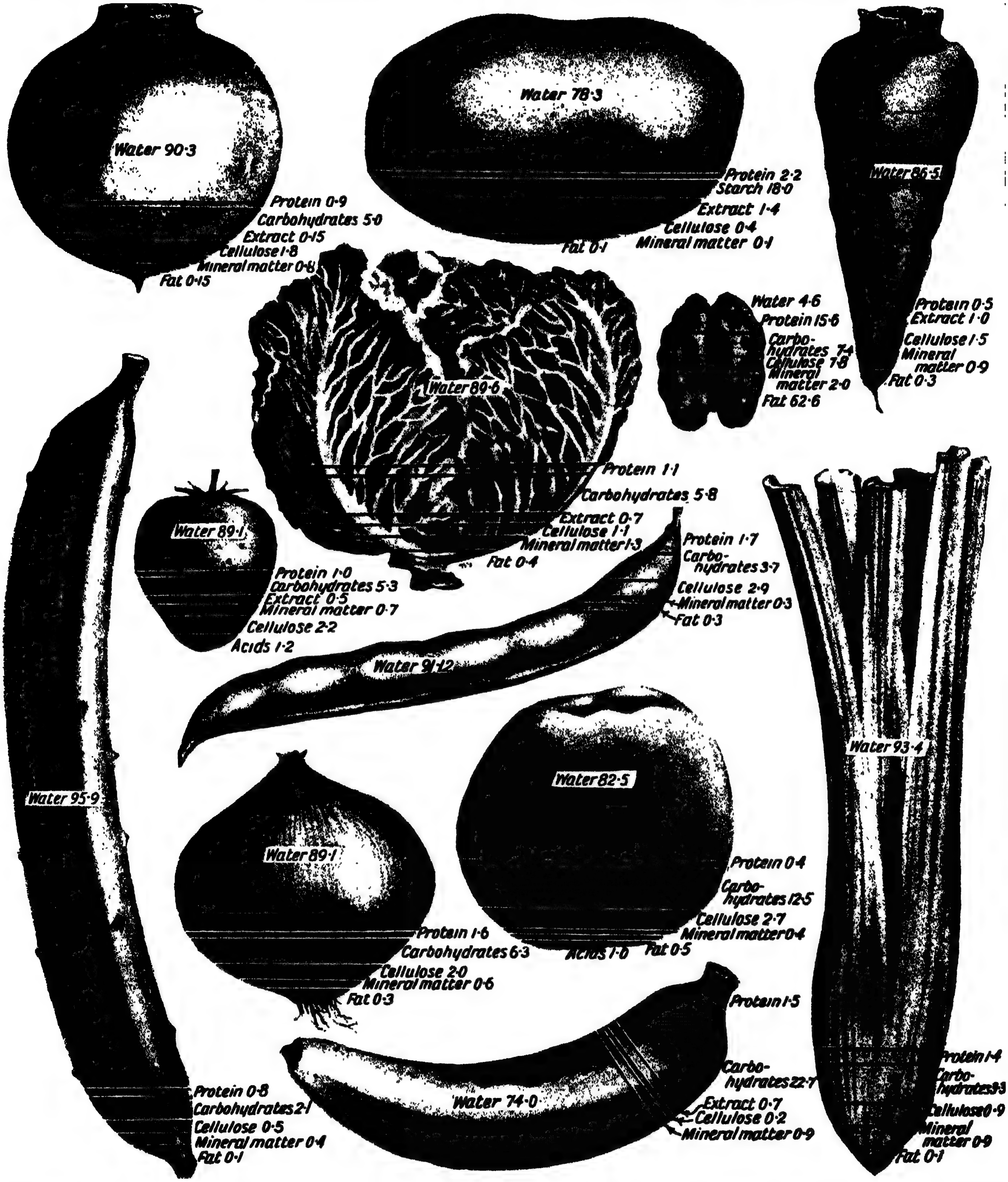
These plants, which sling or catapult their seeds or spores to a distance, are: 1. Squirting cucumber; 2. Teucrium, with enlarged sections showing seed and its ejection; 3. Orobus; 4. Wood Sorrel; 5. Cardamine; 6. Nephrodium fern ejecting spores; 7. Ricinus; 8. Impatiens; 9. Pilobolus, a mould fungus, expelling its spores; 10. Sphaerobolus, a small puff-ball, ejecting balls of spores; 11. Viola; 12. Marsh Crane's-bill; 13. Acanthus

LIFE ON THE EARTH 30 MILLION YEARS AGO

These pictures are the first of a series of reconstructions by Miss Betty Nation, showing what life was like on the Earth in past ages. Here we see life in the Cambrian and Ordovician periods, twenty to thirty million years ago. Life probably began with one-celled plants and animals in the shallow waters. As time went on there developed sponges and jellyfish, and corals and crusted animals called trilobites, and gastropods with single shells and bivalved molluscs. There were also barnacles and shrimp-like crustaceans and crinoids or sea-lilies. Vegetation included seaweeds, and on land primitive horse-tails and club-mosses. There were also possibly a few land insects

This picture shows life in the Silurian period, which began about 18,000,000 years ago, and lasted for some 3,000,000 years. Life was still mostly in the water, although on land the club-mosses and plants like ferns were developed. Sponges, not unlike those which we have to-day, began to appear, and reef-building corals. The sea lilies became larger and finer, and starfishes became more complex. Sea-urchins appeared, and various shell forms multiplied. Creatures with spiral shells of turret form first appeared in this age, and trilobites became more widely distributed. Early forms of king-crab and sea-scorpion were found, and there were fishes of the shark form

WHAT FRUIT AND VEGETABLES ARE MADE OF



We must eat to live, and if we are to grow we must take in plenty of protein, which gives us nitrogen and builds up our tissues, and plenty of carbohydrates and fats, which act as fuel and give us energy. These we get chiefly from animal foods and cereals, but we must also eat fruit and vegetables. These are not very nourishing, but they give us a certain amount of mineral matter which helps to build up our bones, and they also contain very important substances that have only been discovered in recent years and are known as vitamins. These are absolutely essential to good health. Fruits and vegetables are made up largely of water, and the proportions of the different substances are shown in these pictures. Cellulose is of no use for nutrition, but it assists digestion, and so foods rich in cellulose are useful. The fruits and vegetables shown are, reading from the top, turnip, potato, carrot, cabbage, walnut, cucumber, strawberry, runner bean, onion, apple, banana, celery. As can be seen, nuts are different from all the other foods given in that they contain a very large proportion of protein. That is why a good vegetarian diet consists largely of nuts. The starch of the potato is a useful fuel for the body

MARVELS of MACHINERY

THE GREATEST OF ALL MACHINES

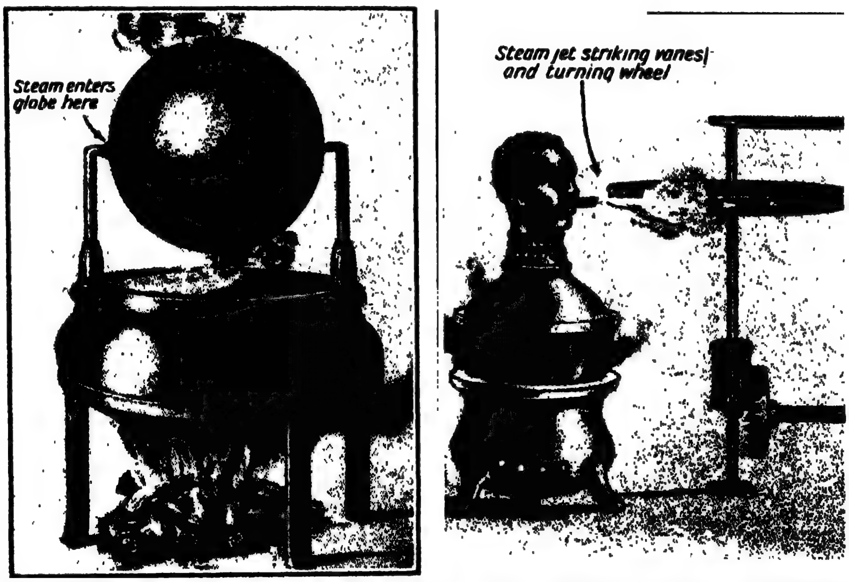
The modern world may almost be described as the product of the steam engine. It is this wonderful invention that has enabled man to travel rapidly in all directions on land and sea, and to produce goods of all kinds in large quantities, adding to his comfort and convenience. For centuries man played with the idea of steam as a motive power, but only at the end of the eighteenth century was the idea made practical, though two thousand years before a Greek had made a very simple form of steam engine that actually worked.

It is no exaggeration to call the steam engine the greatest of all machines, for there can be little doubt that of all the inventions and discoveries made by man that of the steam engine has had the most stupendous and dramatic effect in changing human life and adding to man's comfort and convenience.

Think of what life was like before this great aid to man's labour had come into existence. Things moved very slowly. Work was mostly done by hand, and great factories could not exist, for there was no power to drive machinery even if it had been invented. Transport was slow and difficult; the horse was the Cheltenham Flier of the day, and a journey from Edinburgh to London took a week, or even more in bad weather. A voyage to America might occupy a couple of months, and to Australia five or six months.

Then almost with dramatic suddenness came the steam engine as a practical source of power. Almost at once everything changed. Machinery was invented rapidly for spinning and weaving and doing all sorts of other operations that had previously been achieved only with slow manual labour. The new giant was harnessed to the uses of transport, and locomotives rushed across a network of rails that soon covered the country in all directions. Steamships made journeys across the seas in times that would have seemed fantastic a few years before.

Within a short time the steam engine, "the king of machines" as it has been called, had conquered every civilised country, and most uncivilised lands, too. If we speak of the old times as being divided into the Stone Age, the Bronze Age, and the Iron Age, we may certainly speak of the nineteenth century as being the Age of the Steam Engine.



On the left we see the earliest idea of a steam engine, designed by Hero of Alexandria about 2,000 years ago. Steam from a boiler entered a ball, and as it escaped through two bent pipes it drove the ball round. On the right we see the first modern idea of a steam engine, designed by Giovanni Branca, a seventeenth-century Italian mathematician. Steam from a queerly-shaped boiler blew upon the vanes of a wheel, rotating it and working the stampers of a mill for pounding drugs

This device dominated industrial and social life, and made possible all sorts of amenities that were undreamed of before. People could visit their friends many hundreds of miles away with ease and comfort and speed; they could live in the country and go to the town every day to work, while goods could be produced in unheard of quantities and transported cheaply and rapidly to all parts of the world and sold at a price which would have seemed impossible a few years earlier.

All this remarkable transformation was brought about by the steam engine. Of course, when James Watt made his first steam engine he did not invent the device in the strict sense. He improved what other men had begun, but it almost amounted to an invention, for he made the use of steam as a source of cheap power a practical proposition.

Before his time steam had been used, but only as an auxiliary, for the steam engines of pre-Watt days were slow, clumsy, and inefficient, and worked partly by steam and partly by air pressure and gravitation. Watt was the genius who changed all this.

Two thousand years ago Hero, a mathematician of Alexandria, had the idea that steam could be made to do things. He constructed a globe, we are told, fitted it with outlet pipes, erected it in a frame, and then filling the globe with water, boiled this over a furnace. When steam rushed out of the vents, its pressure against the air rotated the globe.

For centuries man played with the idea, and in the seventeenth century another mathematician, Giovanni Branca, an Italian, actually made a steam engine that did real work. It was a queer contrivance. The boiler was in the shape of a man's head and steam spouted from a pipe between his lips. As it came out it struck upon the vanes of a horizontal wheel which it rotated, and by an arrangement of cogs the wheel was made to work a stamp mill for grinding drugs. Both these ancient engines were really of the turbine type, that is, the energy of the steam at once produced rotary motion. The word turbine is from a Latin word meaning a whipping-top or reel.

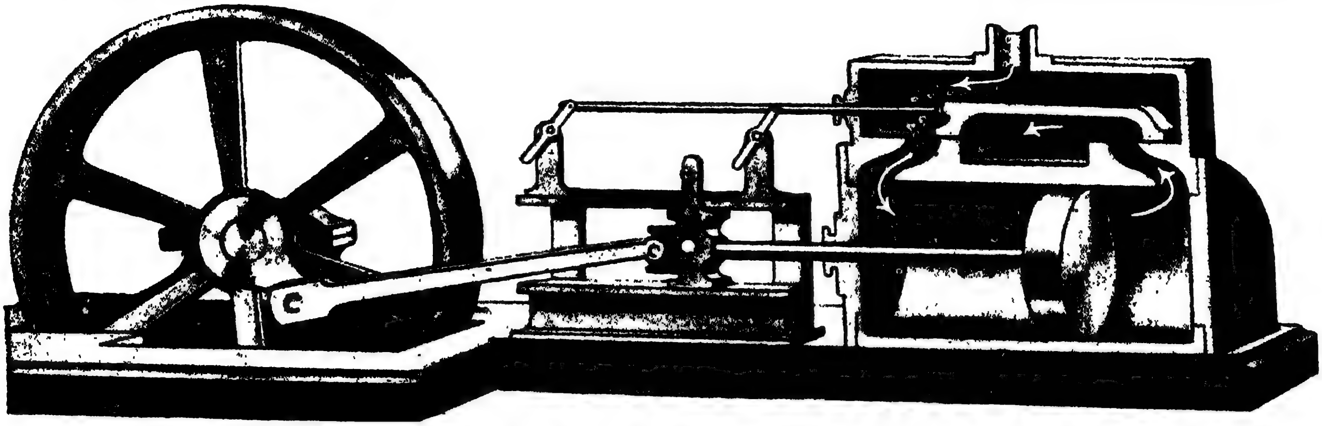
When, in the eighteenth century, Watt and others made engines that were the forerunners of our modern steam engines, these were not of the turbine type, but what are known as reciprocating engines, or to and fro engines, because the motion produced by the steam is first to and fro, and is afterwards changed into rotary motion.

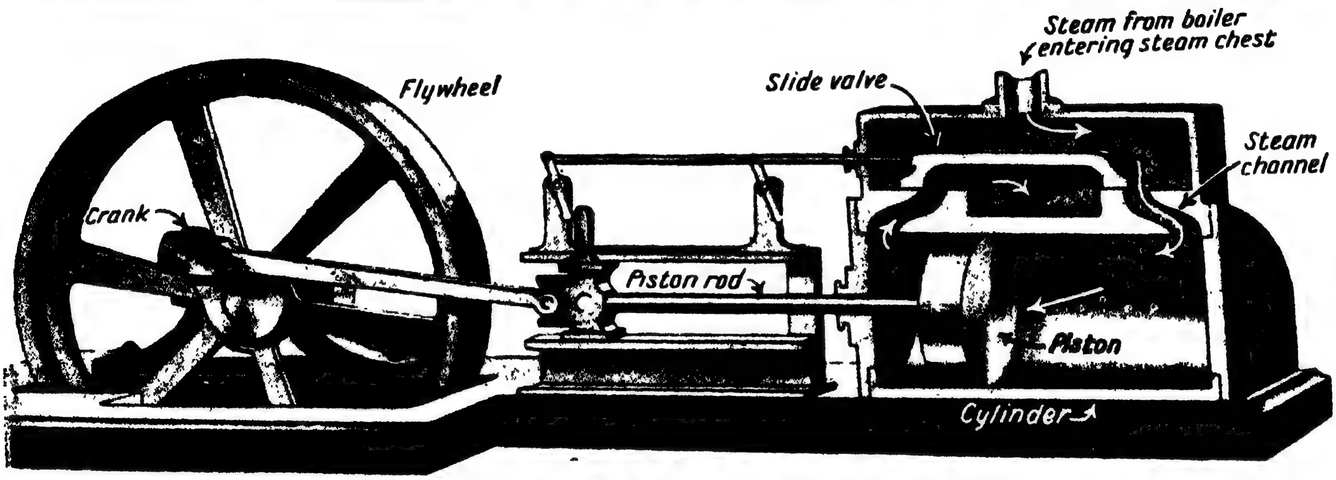
The heat of the furnace turns water into steam, and this is conducted to each side of a piston or plate fitting closely in a cylinder. The steam drives the piston to and fro, and then, by means of a rod attached to it, which is connected with a crank, turns a flywheel and shaft and works machinery

of some kind or rotates the driving wheels of a locomotive and sends it along the rails. The pictures below show clearly how the reciprocating steam engine works.

A steam engine is really a heat engine, that is, it is a machine by means of which heat is transformed into work. It depends for its operation upon the fact that water, when it is turned into steam, expands, and this gives the power to push the piston to and fro. Sometimes after the steam has done its work in the cylinder it escapes through an exhaust pipe, as in the locomotive. There is now an endless variety of steam engines, some of them very complicated, but the principle is the same in all the different kinds of reciprocating engines.

From time to time we hear about steam being superseded, but there is no sign of this at present. Even where electricity is used the steam engine is generally needed to work the generator, and although we hear much of electrifying our railways, the splendid records set up by the steam engines like the Cheltenham Flier show that the steam engine is still able to hold its own.



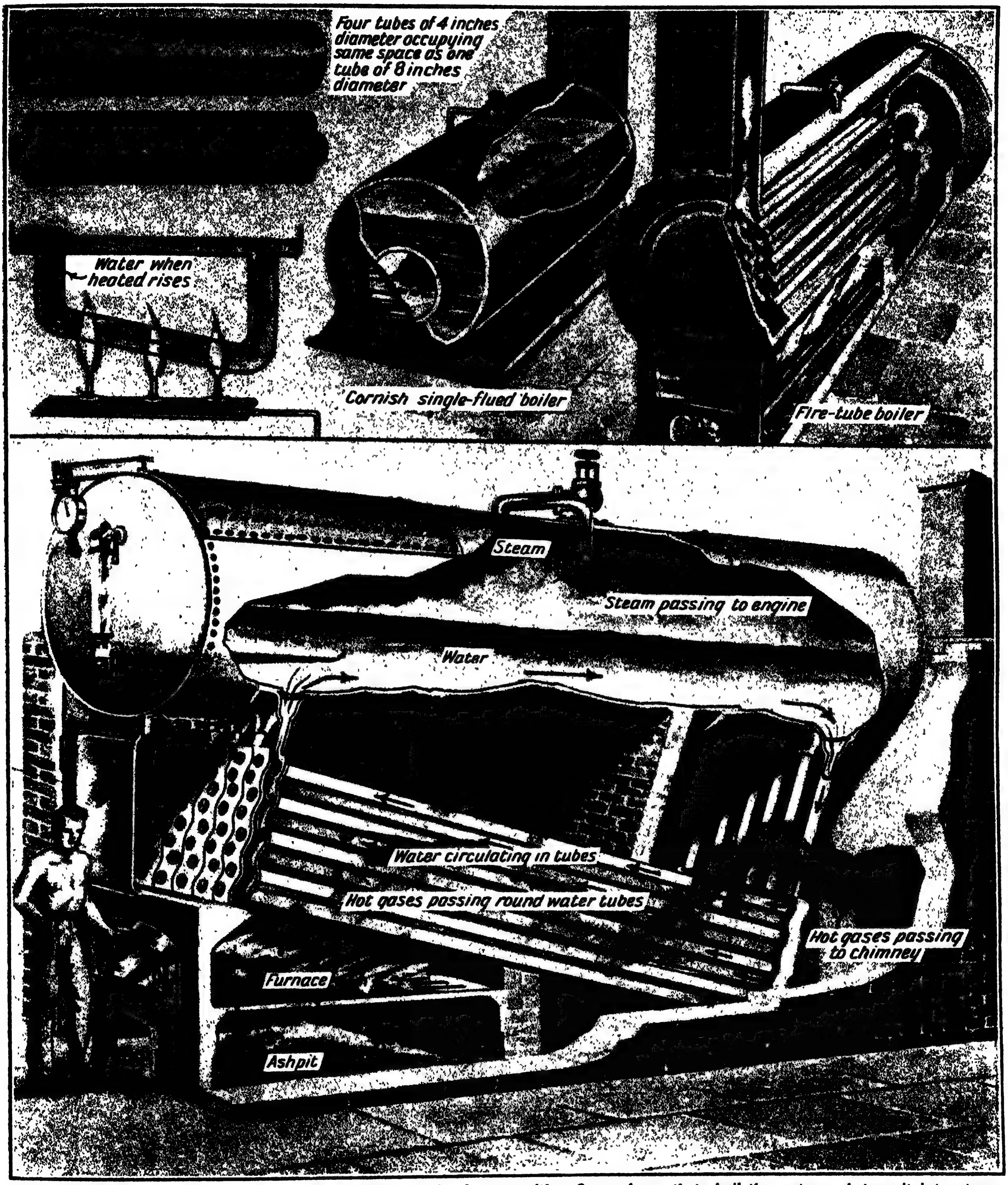


These pictures show in simple form the principle on which the steam engine works. In a boiler, water is turned into steam and conveyed by a pipe to the engine. It enters what is known as the steam chest, and passes through an opening into a cylinder, in which a closely-fitting piston moves to and fro. The force of the steam drives the piston forward as in the upper picture. Connected with it is a rod whose other end is linked with a crank that turns a flywheel, revolves a shaft, and works a machine. As the piston moves forward it works a slide-valve which opens the other end of the cylinder, allowing steam to enter there as in the bottom picture. This presses on the other side of the piston and drives it back, and as it returns the piston sends the used steam, on the rod side, out through an exhaust pipe. Meanwhile, the valve has been reversed and steam again enters as in the upper picture, driving the piston forward once more. As it goes it drives out the exhaust steam on its front side. Thus to and fro the steam drives the piston, working the crank and machinery

HOW THE MORTAR WHICH THE BUILDER USES IS MADE

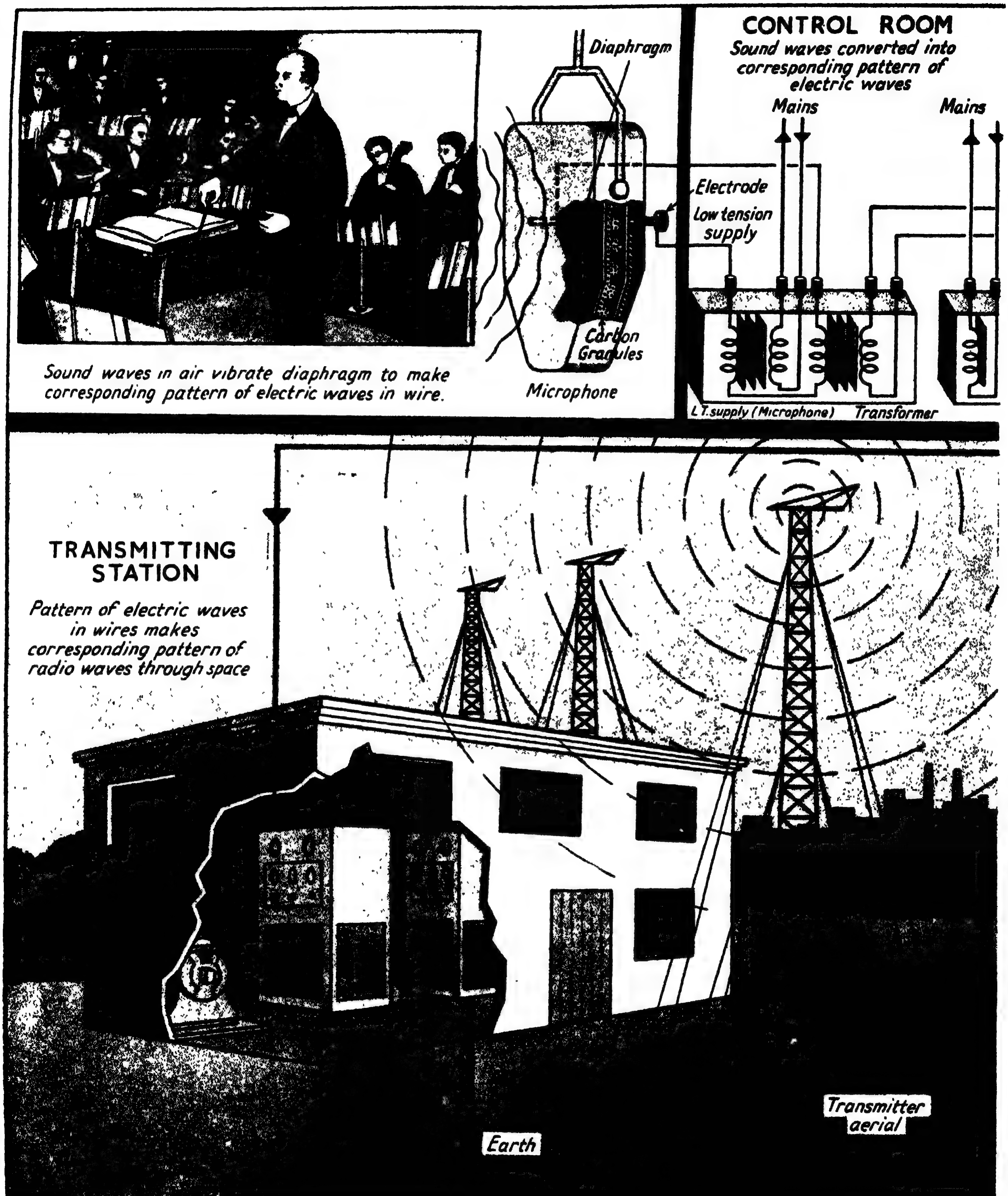
The first step in making mortar is to burn limestone in a kiln, as in the first picture. Carbon dioxide gas is driven off and quicklime is left. Quicklime, mixed with water, as in the second picture, becomes a hot paste known as slaked lime. This, when mixed with sand, as in the third picture, forms mortar, and that enables the builder to stick his bricks together as he builds a wall

WHAT A MODERN BOILER IS LIKE INSIDE



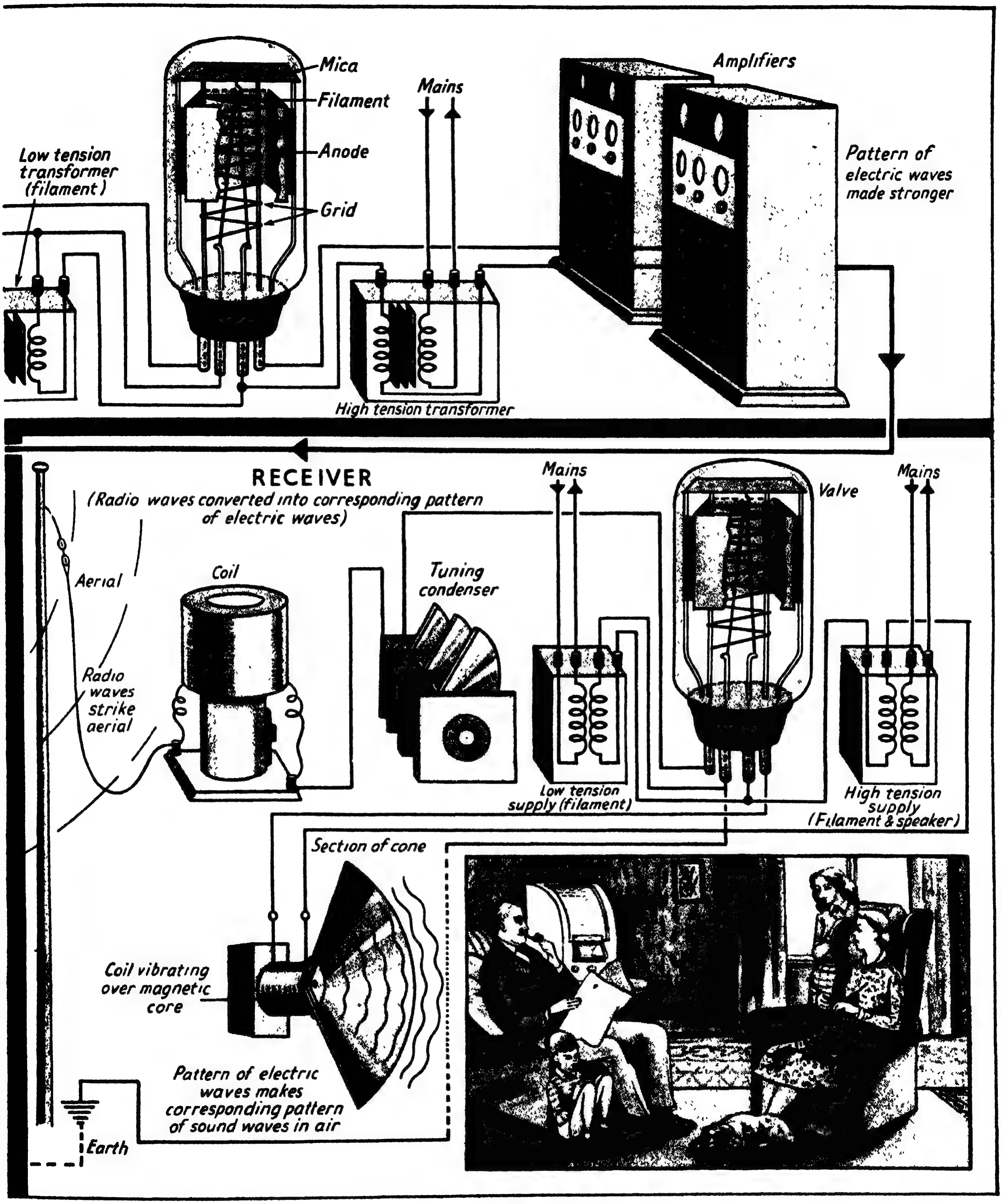
The earliest boilers were very simple affairs, merely vessels of water with a fire underneath to boil the water and turn it into steam, as we do in a kettle. Nowadays a big modern boiler is a complicated machine, so constructed as to get the utmost efficiency from the amount of fuel burned. For a hundred years or more inventors have been improving the boiler so as to increase its heating surface. In the ordinary Cornish boiler the fire and hot gases pass through a single chamber and heat the water which is all round, but an improvement on this is the fire-tube boiler, in which small tubes carry the heat through the water. Here there is a much greater heating surface, for four tubes of 4 inches diameter, though occupying the same space as one tube 8 inches in diameter, have twice the outside surface. But the most efficient type of boiler for raising large quantities of steam quickly is the water-tube boiler. Here the water circulates in tubes and the hot gases of the furnace pass all round. Water rises when heated, and so the tubes are put at a slant

THE WHOLE STORY OF BROADCASTING



When a sound is made it sets up vibrations in the air, and in a radio broadcasting studio these vibrations strike the diaphragm of the microphone. The vibrations press the diaphragm against loose granules of carbon through which an electric current is flowing. The movement of the diaphragm causes the carbon granules to become loose or lightly packed according to the strength of the vibrations, and this makes the current flowing through the granules vary in strength. The fluctuating current then passes from the microphone to the control room where it is increased in strength by transformers and converted into a corresponding pattern of electro-magnetic waves. These pass to the grid of an amplifying valve through which a flow of electrons, induced by an electric current, is passing from

FROM THE B.B.C. STUDIO TO YOUR HOME



the cathode to the anode. As the electro-magnetic waves strike the grid, the flow of electrons between cathode and anode fluctuates in sympathy. This induces similar fluctuations in a high-voltage current which is amplified and passes along landlines to the transmitting station, where it is broadcast into the ether on a carrier wave. The carrier wave with microphone current is picked up by the aerial of the receiving set and carried down into a coil of wire and a capacitor. By manipulating these the current in the set is given the same fluctuations as the current received from the microphone and amplified to operate the electro-magnet of a loud speaker.

The fluctuations of the electro-magnet vibrate a diaphragm, so reproducing the fluctuations in the form of sound

CLEANING A STONE BUILDING WITH STEAM

As we go about London and other large cities we often see men cleaning the front of a building with an apparatus that makes a hissing sound. The apparatus is known as a steam brush, and these pictures show how it works. First of all, a boiler or steam generator is erected on top of the building. From this generator flexible steam pipes pass to the men at work, and at the end of each pipe is a specially designed nozzle with a handle. From this comes a jet of steam at low pressure, and as this begins to condense as soon as it is in the air, a constant spray of very hot water is applied to the surface of the building. The moisture and impact of the steam soften and loosen the dirt, and the moistened grime is driven off by the force of the steam. A travelling cradle is suspended from the top of the building, and this can be raised or lowered or moved horizontally as required. There are ball-bearings in front of the nozzle, which enable it to be rolled about easily over the walls without damaging them. The supply of steam is regulated by a valve-cock

HOW THE BALL-COCK OF THE CISTERN WORKS

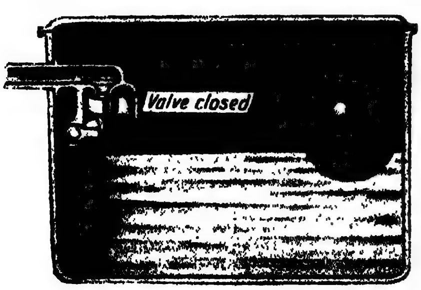
The tanks and cisterns in our houses which contain the supply of water for household requirements or for the flushing of a drain have their supply of water automatically regulated.

When the tank or cistern is empty or the supply is low, water rushes in till it is filled to its proper level, and then the entry pipe is closed so that no more water can go in. This is done by means of a very simple yet clever device known as the ball-cock, and the pictures on this page show how it works.

When the cistern has its full supply a large hollow metal ball attached to a rod floats on top, and the rod is horizontal. The other end of the rod is pivoted and has a valve fastened to it. This, when the rod is horizontal, closes the inlet pipe from the water supply, and no more water can enter.

When the water is drawn off from the cistern, the ball, which floats on the surface, falls by its own weight as the water goes down, and naturally the rod attached to the ball is now at an angle. As the rod descends with the ball, it carries the plug of the valve with it, and so the water pipe is opened and the water can flow in.

When it does so, of course, the level in the tank rises slowly, and with the water the ball rises also gradually closing the entry by means of the valve, as shown in these pictures, until at last the water supply is once more cut off



The cistern ready for use

Water running into the cistern

ROMANCE of BRITISH HISTORY

A DRAMATIC SCENE AT CANTERBURY

When the news became known that Thomas Becket, Primate of England, had been slain in Canterbury Cathedral, the whole of Europe was shocked, for to kill a great Church dignitary was, in those days, regarded as a far more heinous crime than to slay a layman, however exalted. Henry II of England was a strong and powerful king, and though he declared that some idle words of his which led to the tragedy were never intended seriously, he had to acknowledge his fault publicly, and allow the monks to whip him at Becket's tomb. Here the whole dramatic story is told from the old records

Many London schoolboys have risen to high rank and had strangely romantic careers, but certainly of none is a more remarkable story told than of Thomas Becket. He first saw the light in Cheapside, and after going to school in Surrey and in London was sent off to Paris. He was a keen and clever boy and loved to hear about the events of the day. There is little doubt that in the nursery he must have heard of the sinking of the *White Ship* in the English Channel and the loss of King Henry the First's children.

Everything was going well with Thomas when, owing to a number of fires in the City of London, his rich father lost his money and the boy had to return home and begin to earn his own living. He became a clerk in a lawyer's office, but the work must have been very irksome to young Thomas, who loved knightly pursuits.

A Rise to Fortune

After three years, influential friends of his father introduced the young man to the Archbishop of Canterbury, and that prelate was so pleased with Thomas that he sent him off to Bologna in Italy, to study law, and then employed him on many confidential missions.

Those were difficult times in which to live. Kings and princes plotted against one another, but Thomas made himself useful and had a good deal to do with enabling Henry of Anjou to mount the English throne as Henry the Second. Thomas was ordained a deacon, but did not become a priest. Nevertheless, many rich church livings were heaped upon him. He became rector of several parishes, and was made Archdeacon of Canterbury. He also became Chancellor of England.

Thomas, however, did not behave very much like a clergyman. He wore very magnificent dress, and went about with a retinue of knights as splendid as that of the King himself. He spent enormous sums of money, though we do not know where the money came from. His power was as great as his pomp, for the King often went to the Continent, and then Thomas governed the whole realm of England.

There had been great disputes between the King and the Church, the King wanting to control the Church and the Church wanting to be independent. Naturally Henry thought that his great friend Thomas Becket would help him in his plans, but when Thomas was appointed Archbishop of Canterbury an amazing change took place in his life and character. No longer was he the magnificent courtier living amid a pomp that rivalled the King's. He suddenly became the strictest of ascetics, and took up the cause of the Church against the King.

He wore the dress of a monk, and fed and washed the feet of beggars daily. He gave away much in charity, and did strange things which in those days were regarded as signs of holiness. For instance, he wore a hair shirt next to his skin, and deliberately allowed himself to be bitten constantly by vermin as part of his discipline.

Thomas Becket indignantly declines to acknowledge the authority of King Henry's judges

Becket Flees to the Continent

His quarrel with King Henry the Second became the talk of Europe, and so bitter was the struggle that Becket repudiated the King's authority as a judge and fled to the Continent, where he remained for several years in an abbey. From there he wrote angry and threatening letters to those who sided with the King, but at last a peace was patched up and Becket returned to Canterbury, where the people who benefited by his charities received him joyfully.

Then fresh quarrels broke out between Thomas and the King, and this led to one of the most notable tragedies in English history. Becket started excommunicating those who did not agree with him, that is, he cut them off from the benefits of the Church, which in those days were regarded as vital to happiness. He was anything but a tactful man, and everything he did irritated the King, till at last one day Henry, who was in Normandy, burst out before his courtiers in a fierce tirade against Becket.

"What!" cried Henry. "A fellow that has eaten my bread lifts up his heel against me. A fellow that I loaded with benefits dares insult the King and the whole royal family and tramples on the whole kingdom. A fellow that came to Court on a lame horse with a cloak for a saddle sits on the throne itself and no man interferes. What sluggard wretches! What cowards have I brought up in my Court, who care nothing for their duty to their master! Will no one deliver me from this low-born priest?"

A Terrible Decision

Among those who heard these words were four knights of high birth, Sir Reginald Fitzurse whom Becket had originally introduced to court, Sir Hugh de Morville, Sir William de Tracy, a Saxon with royal blood in him, and Sir Richard le Breton, a friend of the King's brother.

These men consulted and came to a dark and terrible decision. They went to England by different routes, arranging to meet at the castle of another knight, Sir Ranulf de Broc, at Saltwood, thirteen miles from Canterbury. Exactly what was discussed there we do not know, but the knights heard that Thomas Becket had been issuing more excommunications, and this only confirmed them in the terrible resolution which they had made.

Christmas had just passed and on the morning of December 29th the knights rode with an escort of horsemen along the old Roman road to Canterbury.

Their escort remained outside, but the four knights entered the court and going to the lodge took off their swords and left them there. Then, throwing gowns over their armour, they walked

across the court to the hall where the Archbishop had just finished his meal.

It is said that Becket had received many warnings that danger was brewing, and there is no doubt that he must have received notice of the arrival of the knights at the palace. After dinner the Archbishop had allowed himself to be flogged, a regular practice of his which he performed as daily penance. Then he went into another room with his chaplain and other friends. With them he sat talking till the bell should ring for vespers in the adjoining cathedral.

The knights asked to see the Archbishop, declaring that they had brought a message for him. They were introduced, but when they went into the room where he was, however, they found that Becket neither spoke nor looked at them, but went on talking. The knights sat down and waited and then, when Becket did not speak but merely glanced at them, Fitzurse said something and ended with the words "God help you." Then he added, "We bring you the commands of the King beyond the sea. Will you hear us in public or in private?" Becket replied that he did not care which, and Fitzurse said "In private, then."

The King's Command

Becket's friends went out, and a heated conversation went on between the knights and the Archbishop. High words could be heard by those outside, but what was said we do not know. Then Becket called in a number of the clergy and told Fitzurse to go on talking.

"Listen, then, to what the King says," continued Sir Reginald. "When the peace was made he put aside all his complaints against you. He allowed you to return as you desired, free to your see. You have now added contempt to your other offences. You have broken the treaty. Your pride has tempted you to defy your lord and master to your own sorrow. You have censured the bishops by whose ministrations the Prince was crowned. You have pronounced an anathema against the King's ministers, by whose advice he is guided in the management of the Empire. You have made it plain that if you could you would take the Prince's crown from him. Your plots and contrivances to attain your ends are notorious to all men So, then, will you attend us to the King's presence and there answer for yourself?"

Warm words followed, and then Fitzurse said, "The King commands you to absolve the bishops whom you have excommunicated without his permission." After further words in which the Archbishop's friends tried to curb his imprudent tongue, Fitzurse, who appears to have been the spokesman for all the knights, said, "Since you refuse to do any of those things which the King requires of you, his final commands are that you and your clergy shall forthwith depart out of this realm never more to return You have broken the peace, and the King cannot trust you again."

Becket declared angrily that he would never again leave England, and nothing but death should part him from his church.

A friend of the Archbishop tried to ward off the blows

At last, amid a scene of anger, the knights started to leave the room, saying to the Archbishop's attendants, "In the King's name we command you to see that this man does not escape."

Becket's Bitter Words

"What," cried the Archbishop, "do you think I shall flee? Never, not for the King nor for any other man."

As they went out Becket followed them to the door excitedly calling after them When he went back into the room his friend John of Salisbury said to him, "My lord, it is strange that you will never be advised. What need was there for you to go after these men and exasperate them with your bitter speeches? You would have done far better to have kept quiet and answered them mildly."

It was now past four o'clock, and on this dull December day the light had almost gone. The knights went back to the palace lodge and called their men to arms. The gate had been closed and the guard was stationed outside with strict orders to allow no one to go in or out. The four knights now threw off their white cloaks and buckled on their swords, and at this moment the vesper bell began to ring out from the cathedral tower Meanwhile, in the palace a monk rushed in breathlessly to the Archbishop to tell him that the knights were arming

"Let them arm," was his reply. "Who cares?"

It is believed that the knights intended to seize the Archbishop and carry him off to one of the knights' castles. When they returned they found the hall door had been closed and bolted. It would have taken a long time to break down the door, but Robert de Broc, who knew his way about the palace, conducted the knights to a staircase in the garden which led to an oriel window opening on to an ante-room next to the hall. The steps were broken, but a ladder was standing near the window, and up this the knights climbed and smashed their way through the casement.

The Vesper Bell

The Archbishop's attendants were in terror and they tried to persuade Becket to pass through a little passage into the cloister and thence into the cathedral. But Becket had told the knights when they went away that they would be able to find him where they had left him, and for a time he refused to leave the room

At this moment the vesper bell ceased ringing, and the attendants reminded the Archbishop that his place was in the church.

Half resisting, he allowed himself to be carried down the passage into the cloister Then he suddenly remembered that his cross had been left behind, and he refused to go on till it was brought to him. He used the interval of waiting to rebuke his followers for their terror.

At last he entered the cathedral, but sounds which immediately arose made it clear that the knights had found the passage and were following him through the cloisters. They approached the door of the cathedral with their swords drawn and axes in their left hands. They were followed by a number of men-at-arms, while before them they drove a crowd of terrified monks.

The service had already begun, and some of those taking part in it, when they saw the armed knights and their followers, ran away and hid in nooks and corners. But others went on with the service as best they could, while one or two braver men went forward to meet the armed men.

Becket did not appear upset at all. He ordered those about him to continue the service. "What is it you are afraid of?" he asked, and when they said it was the armed men, he declared, "I will go out to them."

The Scene in the Cloisters

The knights came rushing on, making a great noise, followed by a motley crowd partly shocked by the outrage and partly wanting to see what was going to happen. Never before or since have the peaceful cloisters of Canterbury Cathedral witnessed such a scene as this.

It was clear that the knights intended harm to the Archbishop, and his followers tried to persuade him to go and hide. He could easily have done so, but Becket was a brave and fearless man, and he would not consent to run away. When his friends went to shut the door to keep the armed men out of the cathedral he ordered them not to do so and said that he would not have the church turned into a castle.

It must have been a weird scene in the cathedral on that dark December afternoon. The only light came from the candles in the Lady Chapel, but these probably were sufficient to show the outline of the Archbishop. Someone cried out, "Where is the traitor? Where is Thomas Becket?" but there was no answer. Then Fitzurse shouted, "Where is the Archbishop?" At this recognition of his title Becket replied calmly, "I am here," and went forward to meet the knights.

"What do you want with me?" he said. "I am not afraid of your swords, and I will not do what is unjust."

The knights took no risk. They closed round the Archbishop crying, "Absolve the persons whom you have excommunicated."

"I will not," replied Becket.

"Then you shall die as you have deserved," cried the knights.

It is quite possible that even when they went into the cathedral they had not intended to kill the Archbishop. It is said that one of them touched him on the shoulder with the flat of his sword and whispered "Fly, or you are a dead man." But Becket was not the type of man that flees from danger.

"I am quite ready to die," he said, "and may the Church through my blood obtain peace and liberty. I charge you in the name of God that you hurt no one here but me."

The news that something unusual was happening in the cathedral had spread rapidly and crowds of townspeople now flocked in. Some of the knights seem to have thought they intended to rescue the Archbishop and the crowd was kept from entering the choir. Becket was standing by a pillar and Fitzurse now seized him and tried to drag him off as a prisoner. But Becket, who had been very calm, now wrenched himself free and cried indignantly, "Off, Reginald, touch me not."

Fitzurse with the help of le Breton and Tracy again seized the Archbishop, but Becket grappled with Tracy and flung him to the ground. Then he placed his back against the pillar and began reproaching Fitzurse, who owed his position to kindnesses received from Becket in the past. This seems to have moved Fitzurse, who whispered to him to fly.

A Deed That Staggered Europe

"I will not fly," said Becket. Whereupon Fitzurse waved his sword over the Archbishop and knocked off his cap. Then Tracy, who had risen from the ground, struck at Becket's head. A friend of the Archbishop, the only one to remain with him, put out his arm to ward off the blow, and as the sword fell it broke this man's arm and he fell to the ground. The sword continued to descend and struck the Archbishop's forehead, so that blood trickled over his face.

The King received five strokes from each bishop and monk

He raised his clasped hands above his head, and then another blow felled him to his knees. He placed his hands together and raised his arms as though in prayer. Then he fell over on his face, and at once another blow was struck at him which severed his scalp.

Immediately one of the knights put his foot on the neck of the fallen prelate and thrust a sword into the wound. That was the final act of the tragedy, and Becket lay dead, assassinated in the Metropolitan Cathedral of the Kingdom. No wonder the terrible deed staggered Europe. It would have created horror to-day, but in those days it seemed an even more terrible deed, for the Church and its ministers were the most sacred institutions that the world knew.

The King Does Penance

The assassins ran out of the cathedral through the cloisters and into the Archbishop's palace next door. There they seized a number of documents and then galloped off. They were never brought to justice, and the blame fell on the King, who was said to have incited them to the crime.

When he received the news in Normandy he seemed stunned. He shut himself in his room, ate nothing for three days, and transacted no business for at least five weeks. Then he expressed his sorrow, promised to do certain penances and received the Pope's pardon.

On his return to England he went to Canterbury, took off his royal dress, put on a hair shirt and a pilgrim's cloak, and with bare feet walked through the streets to the cathedral. At the spot where the Archbishop had been slain he kissed the pavement, then went down to the tomb in the crypt and, flinging himself on the ground, received five strokes with a whip from each of the bishops and monks who were present. There were eighty of them altogether, so Henry must have received 400 strokes from the whip.

Meanwhile the story went round that miracles were performed at the tomb of the dead Archbishop. People had dipped their handkerchiefs in his blood and these also were said to perform wonders. The tomb became a place of pilgrimage and great riches flowed in to Canterbury as a result. Then as time went on the pride and ambition and cruelties of the dead man were forgotten, and he came to be regarded as a saint and as a martyr to the cause of his faith. Even to-day people visit his shrine in the great Cathedral not for the purpose of seeing an historic site, but because they regard Becket as a great and holy man.

The assassination of Thomas Becket in Canterbury Cathedral is as vivid on the page of history to-day as when the deed was committed. It is one of the outstanding incidents of English history which everyone remembers.

WAYS IN WHICH THE WIND HELPS AND HINDERS US

There are many ways in which the wind serves man well and acts as his friend. Even the housewife realises this when she hangs her clothes out on what she describes as "a good drying day." With a warm, dry air blowing at a good rate and the sun shining, it is not long before her clothes are dry. The warmth evaporates the water in the newly washed clothes, and the constantly moving wind carries away the moisture, so that drier air passing by can take up still more of the water from the damp clothes. On a still, cool day clothes do not dry nearly so rapidly, as the air round about the clothes becomes saturated and cannot easily take up more moisture

But the wind is not always the friend of man. When it blows as a fierce tornado, wrecking buildings and hurling tiles and slates in all directions, rooting up trees and blowing down walls and fences, it is a bitter enemy. It is not only in America and other far-away lands that the wind does damage of this kind. This photograph was taken in England, and shows the wreckage left after a gale of wind had passed along a street. Roofs were blown off, windows were smashed, and walls and fences demolished

THE WIND AS FRIEND AND FOE

We rarely think of the air we breathe and which is so necessary to our lives except when the wind is blowing strongly. Then as we have to fight our way against it we realise that the invisible air is really a substance. The wind is both the friend and the foe of mankind. Without it the early mariners could never have crossed the seas and opened up the world for later generations. By its aid, men in early days ground their corn and pumped their water. For centuries it constituted a very important form of power. When, however, the wind blows fiercely, then it can do untold damage. Cities and towns have been wrecked by tornadoes which are only the wind blowing at a terrific rate. Here are some interesting facts about the wind as friend and foe

Some of us like the wind and some of us do not. Little children and feeble old people are blown about if the wind is very strong, and in any case it is annoying to have our hats blown off, or if we are sitting reading the newspaper at the seaside to have the paper carried away or torn by a strong wind.

On the other hand if we are strong and healthy there is something very exhilarating about a walk in the wind. The battle as we fight our way forward is stimulating, and warms us, and we feel that in the face of a strong wind we are filling our lungs with air.

The wind is indeed both our friend and our foe. First of all let us think of the ways in which it is our friend. Without the wind blowing upon the land from the sea and into the town from the country, we should not be as healthy as we are, for it is the winds that give our populous centres a constant supply of fresh air and carry off the smoke and dust of the town or city

Winds Bring Rain

Then we owe to the winds the rains that irrigate our lands and cause the soil to be fertile and productive. The Sun shining on the sea warms the surface and causes a certain amount of the water to rise as vapour and this is carried by the winds on to the land where it meets the rising ground or a colder layer of air and is condensed into particles of water which form into drops and fall as rain.

We also owe to the wind the fact that sailing ships can travel here and there on the seas and rivers and lakes. Of course, we are less dependent upon the wind for transport now than we used to be, for a century and a half ago it was our only means of transport across the oceans, but now the steam or oil engine has supplanted the wind.

To some people these beneficent services of the winds may seem a little remote, but we can come nearer home in estimating the value of the wind. Every housewife knows how useful a good drying wind is on washing day. The clothes are hung out on the line and if there is a strong breeze the dripping clothes are soon dry and ready for the mangle. As a drier of clothes, wet roads, puddles, and so on, the wind is a great friend of man. As it passes over the puddles or articles on the clothes line its warmth causes the moisture to evaporate and this moisture by the constant passage of the wind is carried away while drier air comes in to continue the good work.

We all find the wind a great friend at the seaside, when it brings the invigorating ozone from the sea, enabling us to fill our lungs with the oxygen which our blood needs

But the wind is not always so genial. It has its moments of temper as well as its times of kindness, and when it gets angry it is indeed a terrible foe. Nothing can stand up against it, except the solid mountains.

How Winds Are Caused

The winds are really caused by the Sun. The heat radiated from this ball of fire shining upon the earth warms the sea or land and the air in contact with them becomes warm. This means that it expands and a given quantity is therefore lighter than the upper atmosphere which is not greatly heated as the Sun's rays pass through it. The warm air in contact with the earth being lighter than that above naturally rises as cream rises in milk. Then the colder air rushes down to take its place and so there is a constant movement varying according to the rate and degree at which the lower air is heated.

Sometimes the air above a certain area is heated more rapidly than in the surrounding areas, and then the air rushes in from all round to take the place of the warm air which has risen. When the difference in the temperature and density of two bodies of air is very great the air movements are rapid and a storm is the result. Often when there is cooler air round a district that has

warmer air ascending in a current, the rush of cooler air into this district takes on a spiral movement, and so we call it a cyclone, from the Greek word *kuklos*, meaning a circle The cyclone may be on a very large scale and not very violent. But if it is concentrated and the motion of the wind is violent, we call it a tornado

It is in the tornado that we see the wind at its worst. If this happens on the sea no longer is the sailing ship helped gently forward by the wind It is torn and tossed by a raging hurricane, and is lucky if its masts and sails are not carried away and the ship itself destroyed.

If the tornado passes over the land it may sweep a large area clean of trees, crops, and buildings. One such storm has been known to continue for thirty-five days, and to travel from the Philippine Islands to Central Europe, a distance of more than 14,000 miles.

A tornado will cut through a forest like a scythe through a meadow of hay Even boulders of rock are taken up and transported for hundreds of feet. Animals and human beings are whirled about and sometimes carried for half a mile or more, many being killed in the course of the storm's mad career. Hairpins have been driven through fence-boards and straws have been driven like bradawls into oak trees.

For centuries it was with the friendly co-operation of the wind that man was able to travel about and cross the seas, and even to-day yachts and small craft are glad to make use of the wind in order to plough through the waves

One reason for the great destructiveness of a tornado is that the air pressure in the centre of it may be very much less than in the surrounding area. If it then passes over a closed building, such as a house or factory, in which the air pressure is normal, namely 14.7 pounds on every square inch, while outside the pressure is reduced to 11 pounds to the square inch, then the building explodes outwards. The walls are pushed out with a force equal to 533 pounds on every square foot. In a tornado at St. Louis in 1896 a wooden plank was actually driven by the wind into a steel girder and left sticking in it

Only those who have actually been in a really bad storm can realise the force of the wind. When it is blowing as a light breeze of only twenty miles an hour the pressure it exerts on every square foot is two pounds. When it increases to a strong breeze of forty miles an hour the pressure is then eight pounds to the square foot. In a gale of wind at sixty miles an hour the pressure per square foot is eighteen pounds, and at eighty miles an hour it is thirty-two pounds When the wind reaches a hundred miles an hour then the pressure on every square foot it strikes is over half a hundredweight. It is no wonder that people and motor cars are blown over, houses unroofed and trees and telegraph poles uprooted.

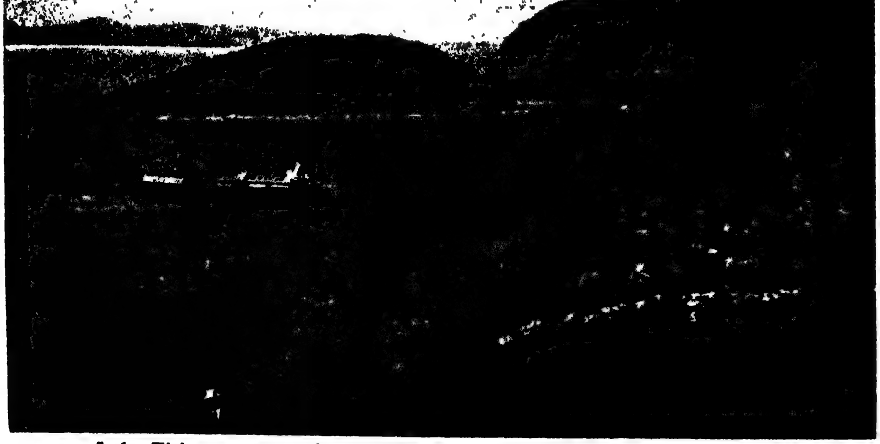
It is not often we get such gales in the British Isles, but in January 1920 at Quilty in County Clare, the wind blew with a speed of 110 miles an hour. So severe are the winds in that part of Ireland that on several occasions on the West Clare Railway, trains have been blown off the metals.

The instrument at Quilty that measures wind velocities is fitted with an electric alarm bell and when the wind exceeds 65 miles an hour this bell rings as a warning and the trains are then specially ballasted to resist the wind. If the speed of the wind reaches 85 miles an hour another bell rings, and all traffic is then suspended so that the trains may not be blown off the track.

A LAKE TWO-AND-A-HALF MILES ABOVE THE SEA

The largest lake in South America is away up in the Andes, nearly two and a half miles above the level of the sea. It is called Titicaca, and is 130 miles long, with an average width of 30 miles. In one part it is nearly 900 feet deep, but at other places it is so shallow that boats often run aground.

There are harbours on its shores and steamboats ply on its waters, which come from the melted snow of the Andean peaks. These flow into it through two rivers on the north shore, and the lake is drained by another river at the southern end.



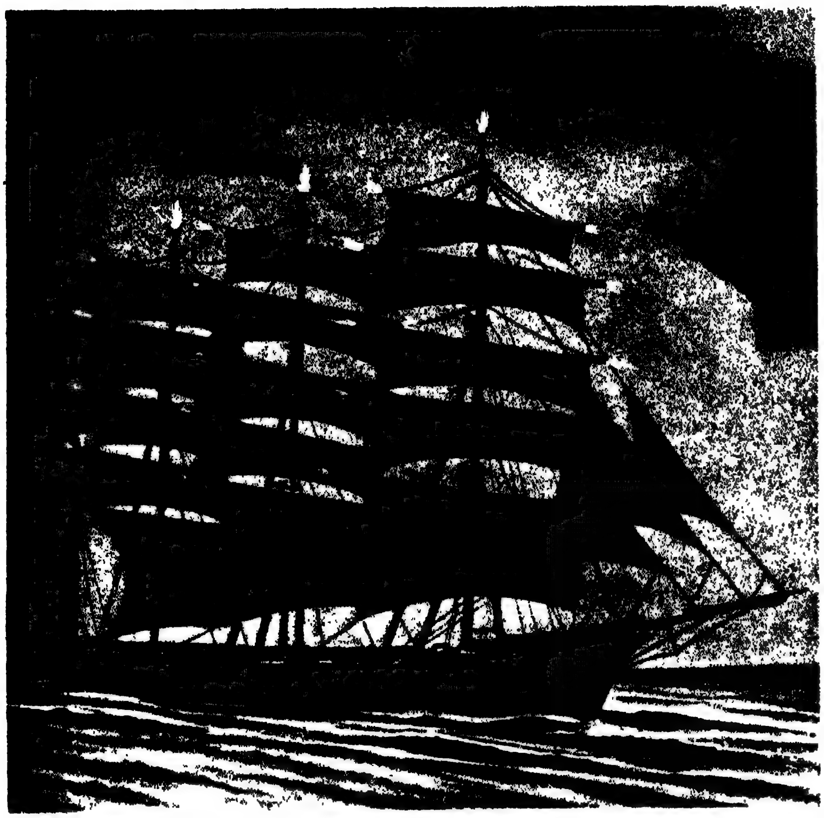
Lake Titicaca, 12,500 feet above sea level, and the Island of the Moon.

Its water is very cold, being not much above freezing point for the greater part of the year. It is never, however, cold enough for ice to be formed. Storms occur on the lake, which belongs partly to Bolivia and partly to Peru, their boundary line crossing near the middle from north-east to south-west. Many fish are caught in the lake and provide a good food supply for people living on the shores.

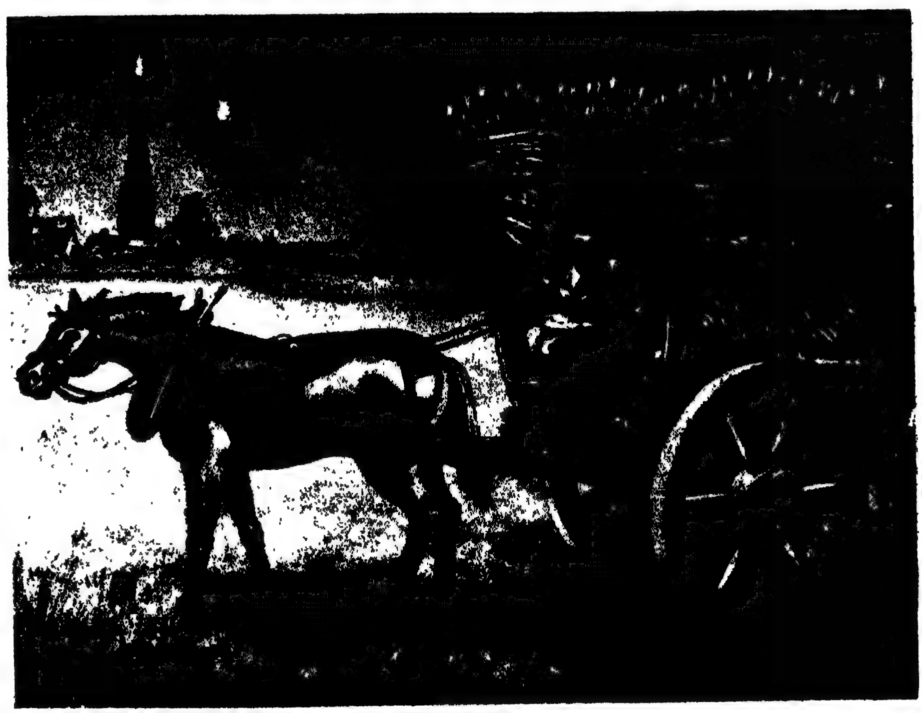
FINE WEATHER ABOVE THE RAINCLOUD

The nimbus, or rain cloud, is a dense, dark sheet of cloud without any particular form, and it may be as low as 200 feet above the ground, or it may be as high as 18,000 feet. Generally it is about three-quarters of a mile. As soon as the cloud becomes overloaded with moisture and its particles of water are too heavy to be sustained in the air, they fall as rain. But above the cloud the sun will be shining, and aircraft pilots have the strange experience of flying beneath a blue sky in sunshine, while underneath them are the black clouds pouring down rain on the city or country below. This picture shows the different weather conditions above and below the clouds

THE STRANGE APPEARANCE OF ST. ELMO'S FIRE



Sometimes a strange and weird appearance is seen by mariners at sea. On the tops of the masts and similar places are seen brushes of pale bluish light, something like the discharge of a frictional electrical machine. These tufts of light are electrical, and are known as St. Elmo's fire. They appear usually during thundery weather, but are also seen occasionally in snowstorms. In the left-hand picture we see a ship with St. Elmo's fire at the masts and yardarms Similar appearances are recorded in ancient times, and we are told that the soldiers of Julius Caesar's fifth legion were once alarmed by noticing that the ends of their spears appeared to be burning. The right-hand picture represents this ancient occurrence of St. Elmo's fire



In the country St. Elmo's fire is sometimes seen playing at the ends of the branches of trees, giving them almost the appearance of Christmas trees lighted up with candles, as shown in the left-hand picture here. Such occurrences have been seen when snow was on the ground. At other times in thundery weather St. Elmo's fire has been seen playing on the spire of a church, and countrymen driving home with faggots or sheaves have seen the strange lights on the ends of their whips and the branches or sticks in the cart

WHAT SHOOTING STARS REALLY ARE

We are all familiar with the "shooting stars" that flash across the heavens from time to time, sometimes leaving a trail of light for a moment or two, and sometimes disappearing with a loud bang, like a rocket exploding. Of course, these are not stars at all, and the scientific name for them is "meteors," a word from the Greek which means "raised from the ground" or "hovering in the air." In these pages we read many interesting things about the true nature of meteors.

If we go into the garden on almost any clear night after dark and look up, we shall see every now and again what appears to be a star shooting across the sky. Such an appearance is popularly known as "a shooting star." What we see, however, is, of course, not a star shooting across the sky, but something quite different.

As we read in other parts of this book, a star is a great fiery world like our Sun, but these "shooting stars" are quite small fragments, some the size of a pea, others the size of a walnut, and others perhaps larger. The name scientists give to them is meteor, a word from the Greek which means a thing raised up beyond the Earth's surface.

It is important that we should know exactly what meteors or "shooting stars" are, for in the old days when the mass of people were ignorant they greatly feared these appearances. It must be explained then that these points of light travelling rapidly across the sky, some times leaving a trail of light behind them, are fragments of matter rushing through space, and as the Earth moves in its orbit round the Sun it meets or is overtaken by these fragments. They are travelling very fast, at anything from ten to thirty miles a second. Perhaps their average speed is about 25 miles a second.

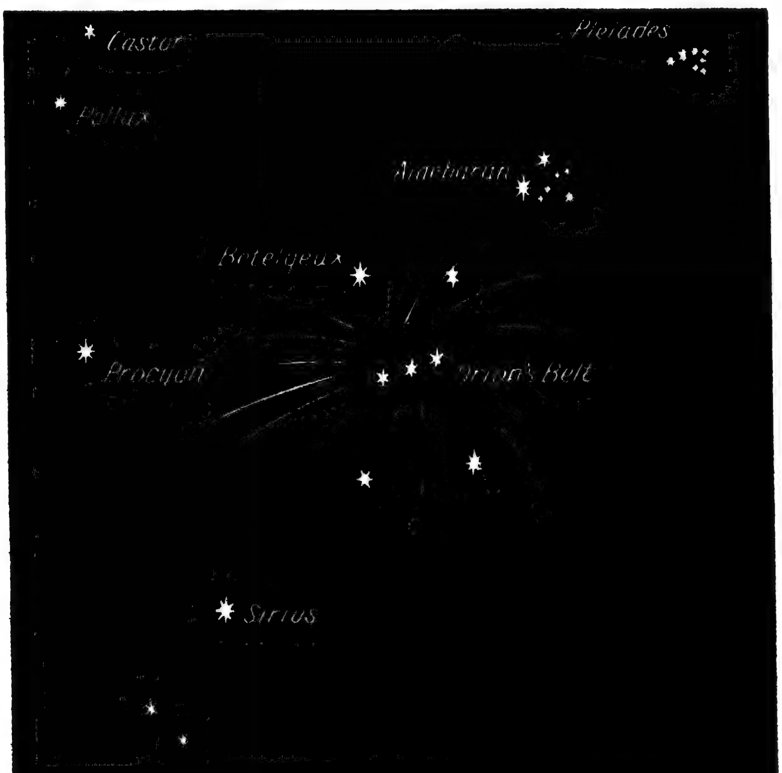
The Air as a Brake

Attracted by the Earth's gravitation a meteor rushes into our atmosphere and almost at once the air acts as a brake, slowing down its speed. The result is that the stone becomes white-hot and is visible to an observer on the Earth. When it is first seen it is generally at a height of about 74 miles above the Earth, and then when it is some 50 miles away it disappears.

Why does it disappear in this way? Well, the reason is that the friction as it rushes through our air causes such heat that the meteor is burnt up; part goes off in gas, and the rest, as fine dust, falls upon the Earth.

Burning Showers in the Sky

There are certain seasons of the year when meteors are often seen not singly but in showers. Hundreds of them are seen in a short time, all apparently radiating from a single point in the sky. For instance, at the end of June, we often see showers of meteors, and these are known as Draconids, because they appear to come from the constellation of Draco, the dragon. Towards the end of April we often see another shower of meteors rushing through the air and known as the Lyrids because they seem to come from the constellation Lyra, the harp.



A picture diagram showing how the Orion meteors, which are generally seen between October 17th and 24th, radiate from the constellation of Orion. At other times numbers of meteors radiate from other constellations, like the Leonid meteors from Leo, between November 13th and 15th, and the Andromedid meteors from Andromeda, between November 17th and 23rd

About August 10th yet another shower apparently comes from the constellation Perseus, and is known as the Perseids. Then there are the Orionids often seen in the middle of October radiating from the constellation of Orion. In the middle of November the Leonids are seen coming from the constellation of Leo, the lion, and toward the end of November there are the Andromedids coming from the constellation Andromeda.

These are not the only meteor showers that appear. There are various other showers at other times, but these are the chief. Sometimes the showers occur every year, and at other times only at intervals of several years. Now these showers of meteors are not all alike. For instance, the Perseids have a yellow light, while the Leonids show a bluish-green tint, and the Andromedids are reddish. The differences are due to the direction from which the meteors come into our atmosphere.

The Meteors' Path

We know that if a train is travelling at thirty miles an hour and another overtakes it and runs into it at fifty miles an hour, the force of the collision is the same as if a train going at twenty miles an hour ran into a stationary train. If, on the other hand, a train going at fifty miles an hour meets a train coming in the opposite direction at thirty miles an hour, the force of the impact is eighty miles an hour.

Now when our Earth crosses the path of a shower of meteors and we meet the fragments coming towards us, the speed with which they rush into our atmosphere is far greater than if the meteors overtake our Earth travelling in the same direction or than if they strike us sideways. The greater the speed with which the Earth's atmosphere

and the meteors collide the greater will be the heat generated. The Leonids, for instance, are met by our Earth and so, becoming very hot, they shine with a vivid bluish-green tint, whereas the Andromedids overtaking the Earth become much less heated and shine with only a reddish light.

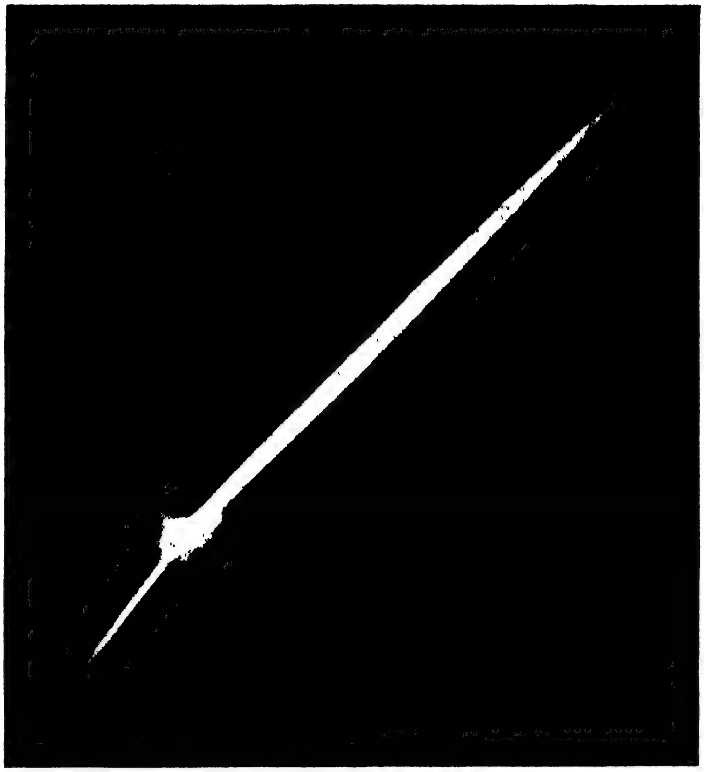
What are these showers of meteors?

Why are there so many fragments together, and why do the showers sometimes persist for days? Well, all meteors are probably fragments of something that has been broken up in past ages.

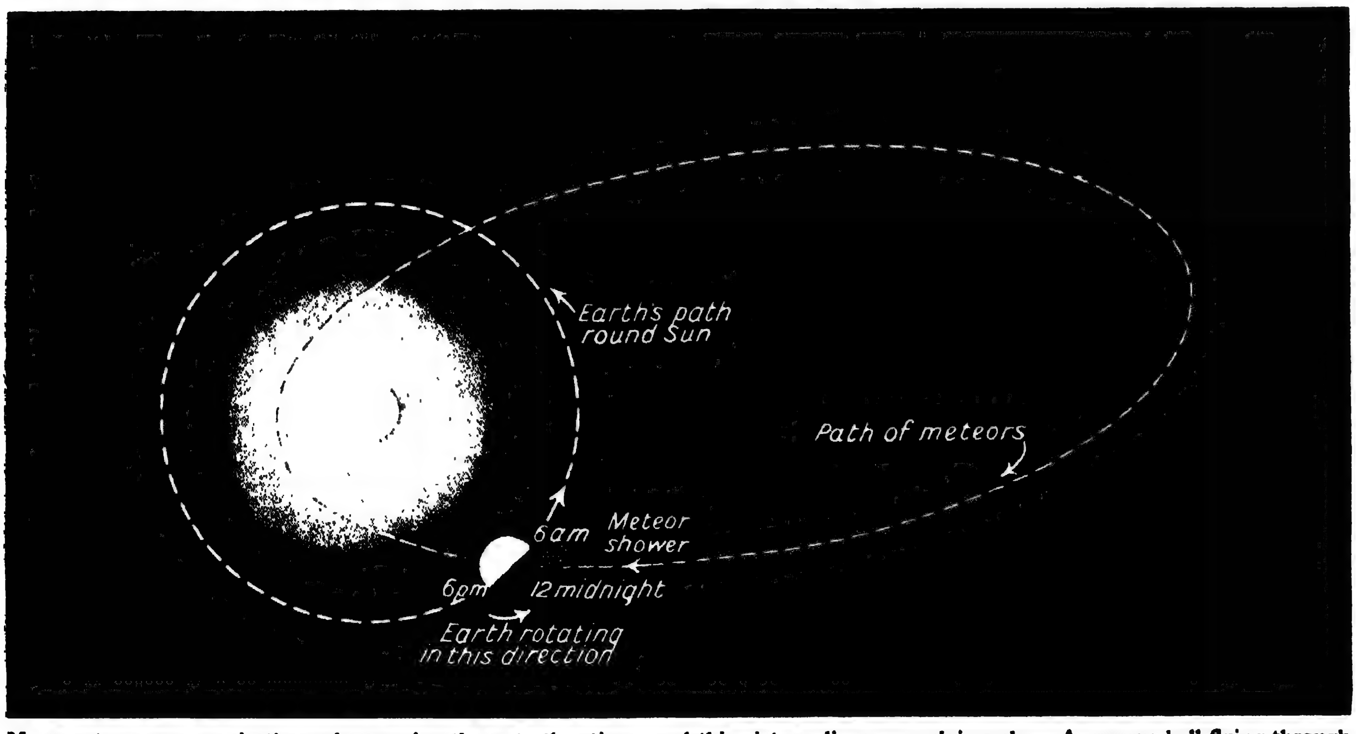
Just as the Sun is supposed to have been broken by the pull of a passing star with the result that the planets were drawn off, so it is thought by astronomers that in some way other heavenly bodies were broken up into fragments and that these fragments came to form comets with regular orbits round the Sun. Then in course of time some of these comets became broken up and so when our Earth crosses the path of a swarm of meteors it is really crossing the path of some extinct comet. The fact, that in certain cases when a comet has been due to arrive, meteors have come instead lends support to this theory.

In some cases it is believed that the fragments are scattered throughout the orbit, as in the case of the Perseids, and then the shower is seen every year and may continue for a week or two while the Earth is near the path of the meteors. On the other hand, in some cases the shower of meteors occurs on one day only, as in the case of the Leonids and the Andromedids. In that case it is believed that the meteors are not scattered throughout the orbit but are concentrated, and we thus see a shower only at the actual time of crossing the orbit. Further, such showers occur only at intervals of years, for these concentrated groups of meteors only happen to be where the Earth is passing at long intervals.

Some people have an idea that "shooting stars" or meteors are of rare



A remarkable photograph of an Andromedid meteor exploding in the upper atmosphere. The explosion of meteors is believed to be due to the expansion of gases within them, caused by the terrific heat that results from friction with the Earth's atmosphere. This photograph was taken by Mr. C. P. Butler, a Cambridge scientist, and published by courtesy of the Royal Astronomical Society



More meteors are seen in the early morning than at other times, and this picture diagram explains why. A cannon-ball flying through a swarm of gnats would catch most insects on the side that first entered the swarm. Now meteors are circulating in an orbit, which the Earth's orbit crosses. As the Earth reaches the orbit of the meteors it is in the position shown here, where we are looking down upon the Earth, Sun and meteors. It is 6 a.m. on that portion of the Earth that is running into the meteor swarm, and although meteors are flying towards the Earth from all quarters, the Earth's front, or forehead, as it were, encounters the largest number, just as the front of the cannon-ball caught most insects. When twelve hours later these places have reached the spot where it is 6 p.m., the smallest number of meteors will be seen, because only those travelling faster than the Earth can strike it, coming up as they do behind

occurrence, but this is far from being the case. Professor Newton has estimated that the number entering our atmosphere every day, and visible to us, must be between ten and twenty millions, and another astronomer believes, that in addition to those which are visible to the naked eye, there are at least a hundred millions entering our atmosphere daily which can be seen only with the aid of a telescope.

Meteoric Dust

That these meteors add appreciably to the weight or mass of the Earth is beyond doubt. It is difficult to trace dust from meteors upon ordinary ground, but scientists in Greenland and other parts of the Frozen North have collected large quantities of the meteoric dust by melting the virgin snow. In Spitzbergen, for instance, Dr. Nordenskiold melted several tons of snow and then filtered the water. As a result he obtained minute particles of oxide and sulphide of iron, substances that are known to have come from meteors.

The average meteor weighs only the fraction of an ounce. There are so many, however, that Professor Young points out that if we assume 20 million meteors a day, each weighing one-sixtieth of a pound, the total amount of matter added to the Earth would be 50,000 tons a year, yet it would take 800 million years for the meteors at this rate to add a layer an inch thick to the whole of the Earth's surface.

Perhaps the most remarkable display of meteors was that of the Leonids on November 12th, 1833. Observers reckoned that as many as 200,000 were seen every hour for five or six hours. As one scientist says: "The sky was as full of them as it ever is of snowflakes in a storm." There were so many that an old lady said they looked like a gigantic umbrella.

A large meteor exploding in the sky with a loud detonation. These explosions are believed to be due to some of the materials in the meteor being rapidly turned into gas by the heat of the Earth's friction

Of course, occasionally a fragment much larger than the average happens to enter the Earth's atmosphere and does not get completely burnt up before it strikes the Earth. Once or twice large meteors have actually reached the Earth and done great damage, but of these we read in another part of this book.

Changing the Year

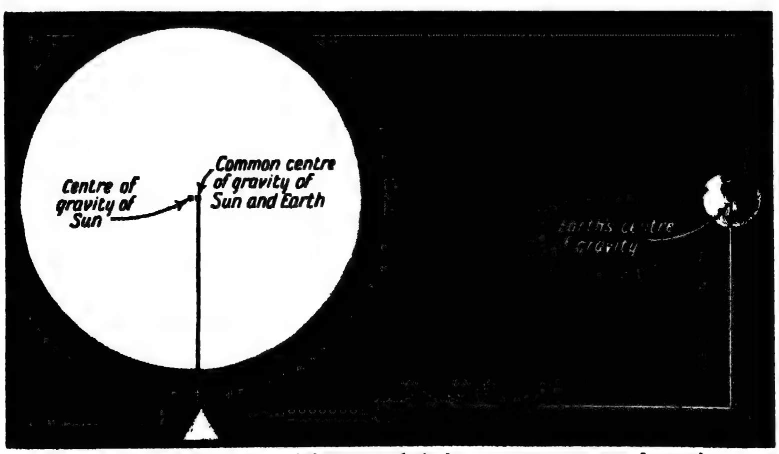
But even those that reach the Earth as dust and gas have a curious effect, for slowly they are diminishing the length of our year. Of course, it is to such a small extent that we cannot notice it. By mathematics, however, it can be calculated that the combined effect of all the meteors that reach the Earth reduces our year by about one thousandth of a second in a million years. This reduction of the year is due to various causes, but chiefly to the fact that the mass of the Earth is increased, which results in a greater attraction between it and the Sun and, therefore, an increased speed in travelling round the orbit.

Meteors bring a certain amount of heat to the Earth, but all the meteors that come to the Earth in a year give us no more heat than the Sun does in a tenth of a second.

HOW THE SUN AND EARTH GO ROUND AND ROUND

While it is true that the Sun attracts the Earth and keeps it circling in its orbit instead of rushing off into space, it is equally true that the Earth attracts the Sun, although, of course, being so small compared with the Sun, its attraction is little noticed.

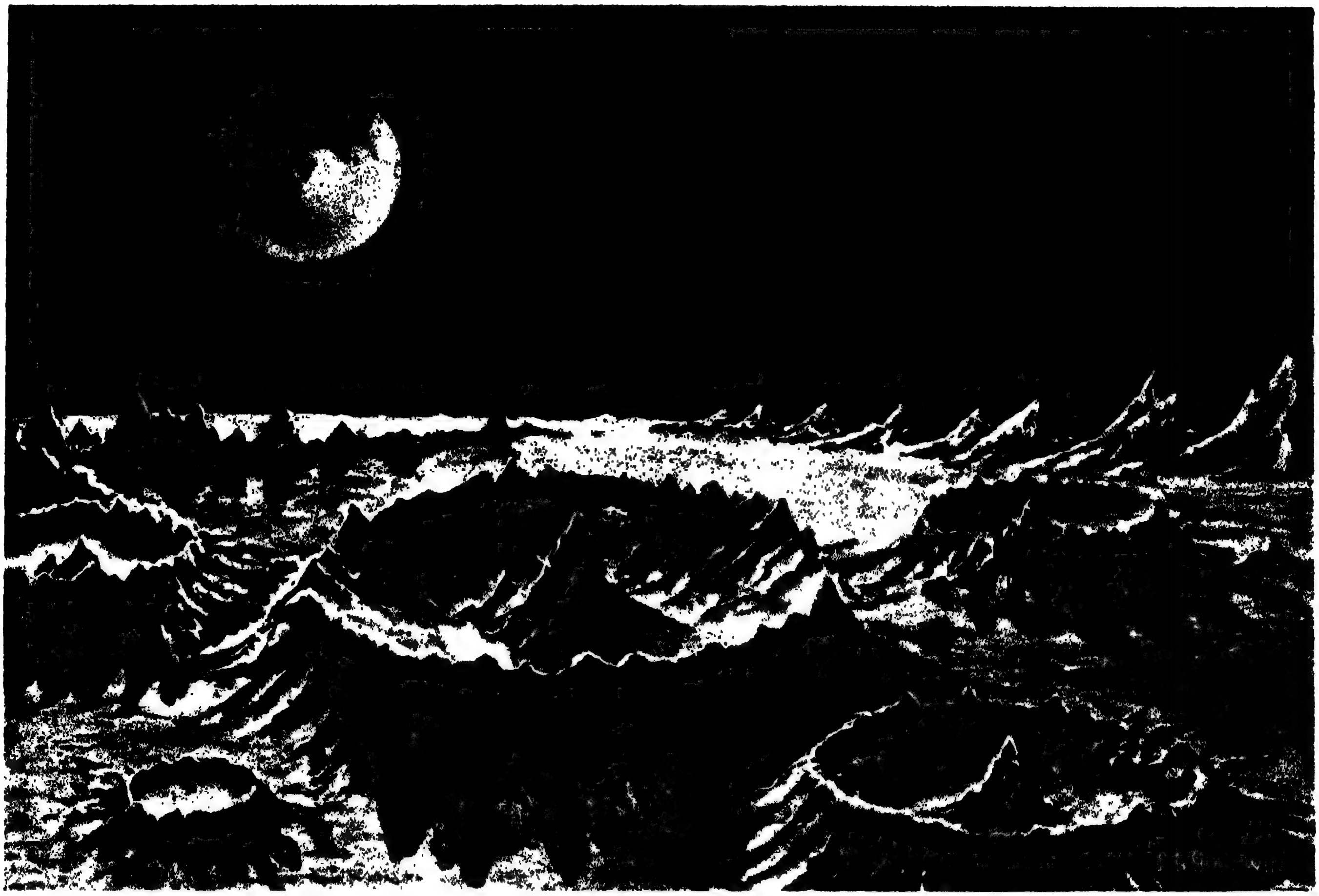
If two bodies in the heavens circling round one another were of the same size and mass, they would revolve round their common centre of gravity, which would be exactly halfway between the two.



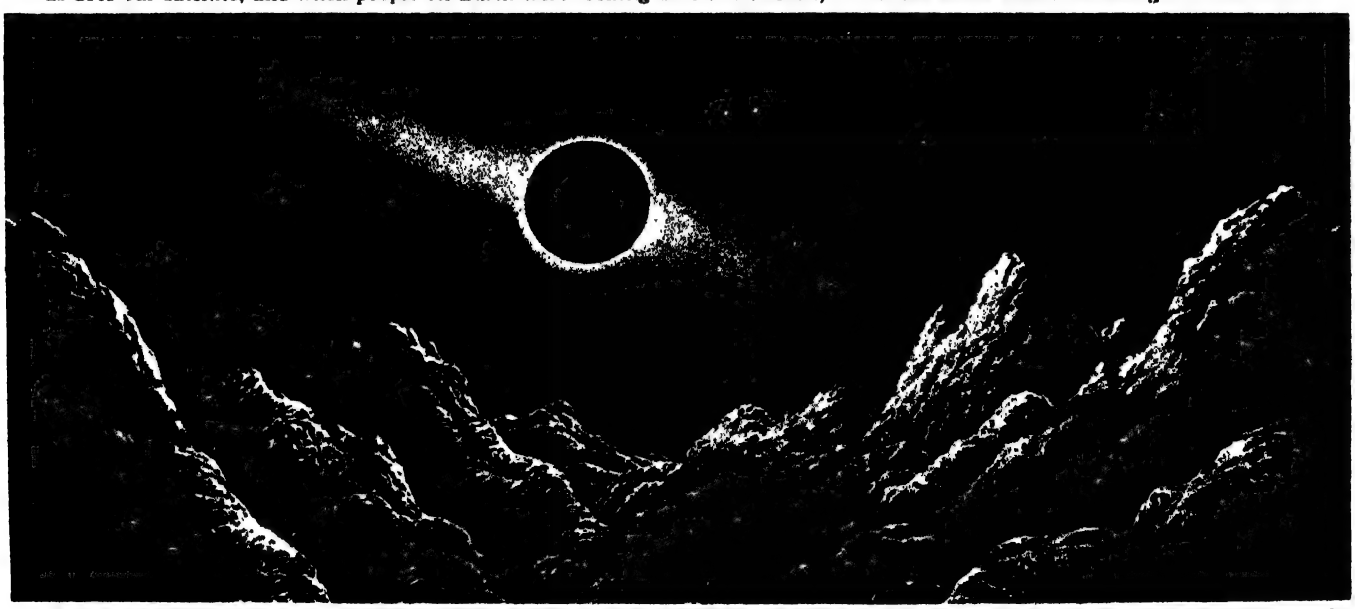
The Sun and Earth revolving round their common centre of gravity

In the case of the Sun and the Earth the same kind of thing happens, but the mass of the Sun is so enormous compared with the Earth that the common centre of gravity round which they both revolve is almost at the Sun's centre. This diagram shows the fact pictorially, and we can see that the Sun's revolution is little more than rotation on its axis, whereas the Earth goes round the Sun at a distance of over ninety million miles. In the diagram the sizes of Sun and Earth are not to scale.

THE EARTH AS SEEN FROM THE MOON



If it were possible for us to make a journey to the Moon, carrying our own oxygen with us, as there is no atmosphere on the Moon, we should be able to look up and see our Earth shining in the sky like a much bigger and more glorious Moon. This picture shows the kind of scenery that there is on the Moon, with its great craters surrounded by high walls, and with smaller peaks inside. The Earth would appear with a diameter four times as great as that of our Moon, seen from the Earth. It would pass through various phases, as does our satellite, and when people on Earth were looking at the full Moon, we on the Moon would be seeing the new Earth



The Sun in his apparent daily course would at times pass actually behind the Earth, and then if we were on the Moon we should have the very magnificent spectacle of a total solar eclipse, a far more imposing sight than any eclipse can appear from our Earth. When we see the Moon eclipse the Sun the almost similar diameters of the two discs in the heavens render the duration of the total eclipse extremely short—seven minutes at the outside. To a lunar spectator, however, the Earth appearing four times the apparent diameter of the Sun, and the Earth seeming relatively stationary in the heavens, the total eclipse would extend over several hours. During the passage of the Sun behind the Earth's disc there would be a magnificent succession of luminous phenomena, and the whole lunar landscape, covered by the Earth's shadow, would be illuminated with faint crimson light

WHY A SMALL GIRL CAN PLAY A BIG TRUMPET

There are all sorts of trumpets, but none of these depends for its music upon the force with which the player can blow into the mouthpiece. The different notes are produced by varying the length of the tube, and this is done sometimes by pushing the tube in and out, as in the trombone, and sometimes by means of pistons, worked by keys, as in the cornet. Here the whole matter of trumpet playing is explained.

A GOOD many people, when they see a military band pass by, with some of the men carrying large brass or silver instruments such as the euphonium and bombardon, are astonished that men who are marching rapidly can find enough breath to play these instruments.

Most of us, when we have walked a good distance quickly, especially if we are going uphill, are almost out of breath. Yet the bandsmen will play their trumpets, cornets and other wind instruments quite as loudly at the end of a march, even if they are going up a slant, as at the beginning of the march on a level road. How is it that they can do this ?

There is no mystery about the matter, for the man who plays a trumpet does not get from it the sounds by blowing furiously into the mouthpiece and passing through the trumpet the air which he has previously drawn into his lungs through his nose As a matter of fact, very little of the man's breath ever passes through the instrument at all.

If we realised how much air is enclosed in the brass instrument compared with that inside the player's lungs, we should at once understand that the instrument is not played by blowing volumes of air through it. What happens is that the player places his lips against the mouthpiece of the instrument and then, by vibrating his lips, sets the whole of the column of air in the instrument also vibrating, and it is this vibration which gives the sound. That is why the fact that a young girl is able to play a cornet or trumpet quite well should give us no surprise.

It is not a matter of lung power, but of skill in the use of the lips. In the brass band what is required to play the instruments well is not great strength of lung, but much practice. Trumpets and similar instruments consist of a tube widened out at one end into a cone or bell, and gradually narrowed towards the other end until there is a very small aperture. Then, in order that the lips may be placed to this aperture in such a way that the connection is airtight, the tip is widened into a conical or hemispherical cavity known as the mouthpiece.

Tubes of different lengths and diameters give different notes, and while the diameter of an instrument cannot be varied, the length can be, and this is done by a number of ingenious devices. We may have seen photographs of Tibetan priests playing very long trumpets, often two or three times as long as themselves. Well, the men in a brass band in England often play a trumpet whose tube is very much longer than their own height.

In order to make the instrument convenient for handling and carrying, the tube is bent about or coiled up. For instance, there is an instrument known as the French horn, in which the tube is very much curled about. The instrument is not much more than two feet across, but if the tube were straightened out it would measure seventeen feet from mouthpiece to bell opening.

In one type of instrument, the trombone, the different lengths of tube for the different notes are obtained by sliding one part of the instrument up and down, thus increasing or shortening the length. In that type of instrument there are no pistons to be pressed up and down by the fingers, as in the cornet, for the sliding of one part of the instrument in and out of the other provides the necessary variations of length.

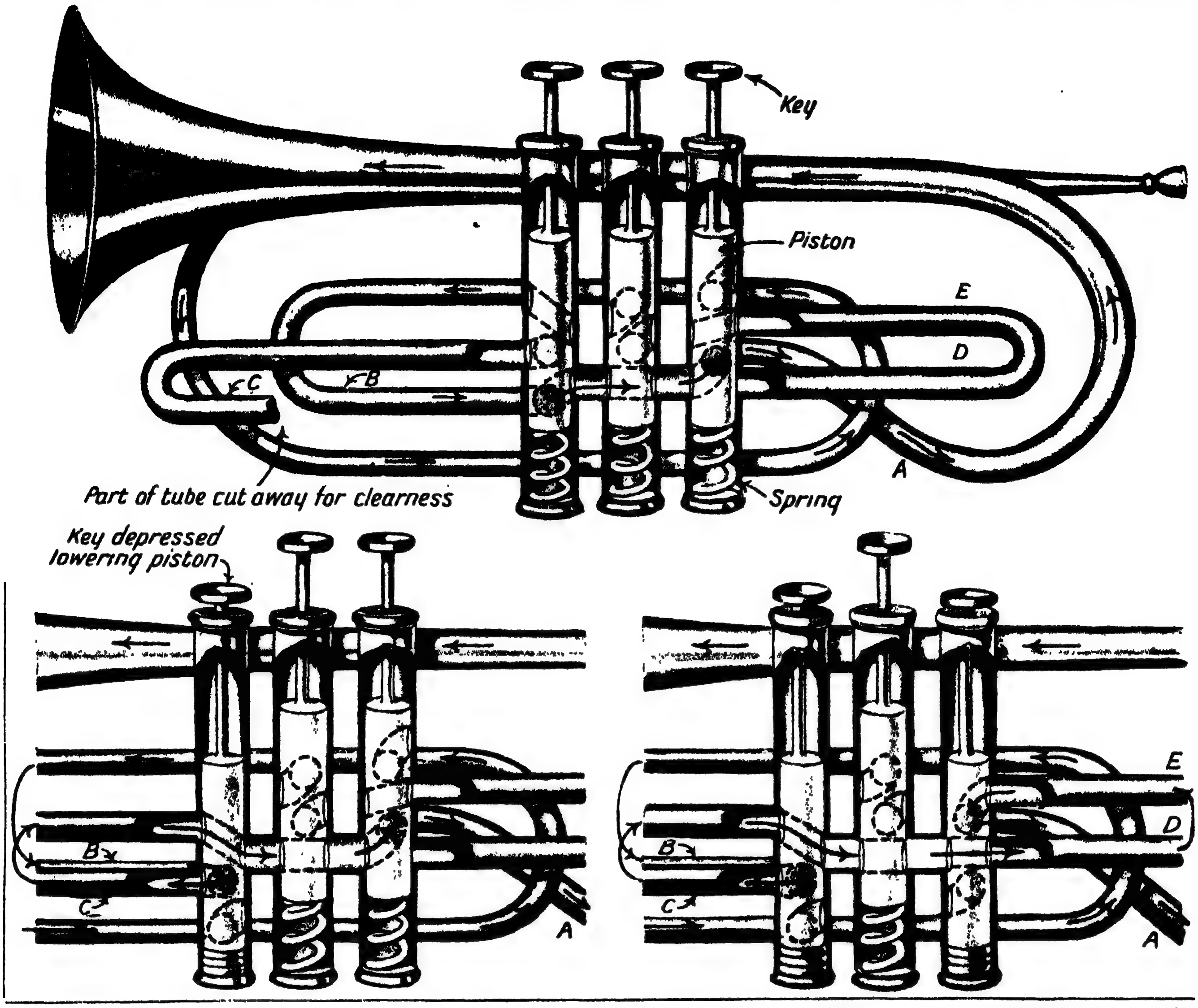
When we come to the cornet, however, the chief soprano brass instrument, the variations in the length of the tube are obtained by valves inside, which are worked by pistons. These valves, according to which piston is pressed with the finger, shut off or open up certain coils of the tube. The length of that part in which the air is set vibrating between the mouthpiece and the bell or cone is varied.

A girl can play a trumpet as well as a man, for the notes are not produced by furious blowing, but by vibrating the lips and setting the column of air in the instrument also vibrating

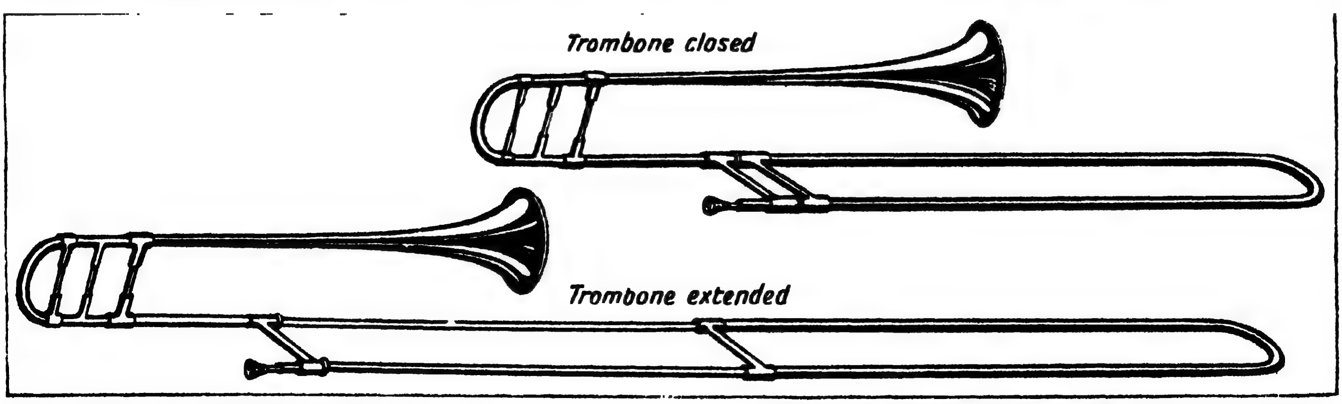
The cornet of the brass or silver band is quite a modern instrument. In its present form it dates only from the nineteenth century. The cornet mentioned in Shakespeare's plays was a different instrument made of wood.

The cornet has no fixed notes like those of a woodwind instrument with its holes or keys. The different notes of the musical scale are obtained partly by the player varying the tension of his lips and the pressure of his breath, and partly by using the three pistons, and the changes of key or pitch are also obtained by means of the pistons and valves. In other words, the note is made high or low by changing the length of the tube, and thus varying the size of the column of air which is set vibrating.

THE INGENIOUS MECHANISM OF A CORNET

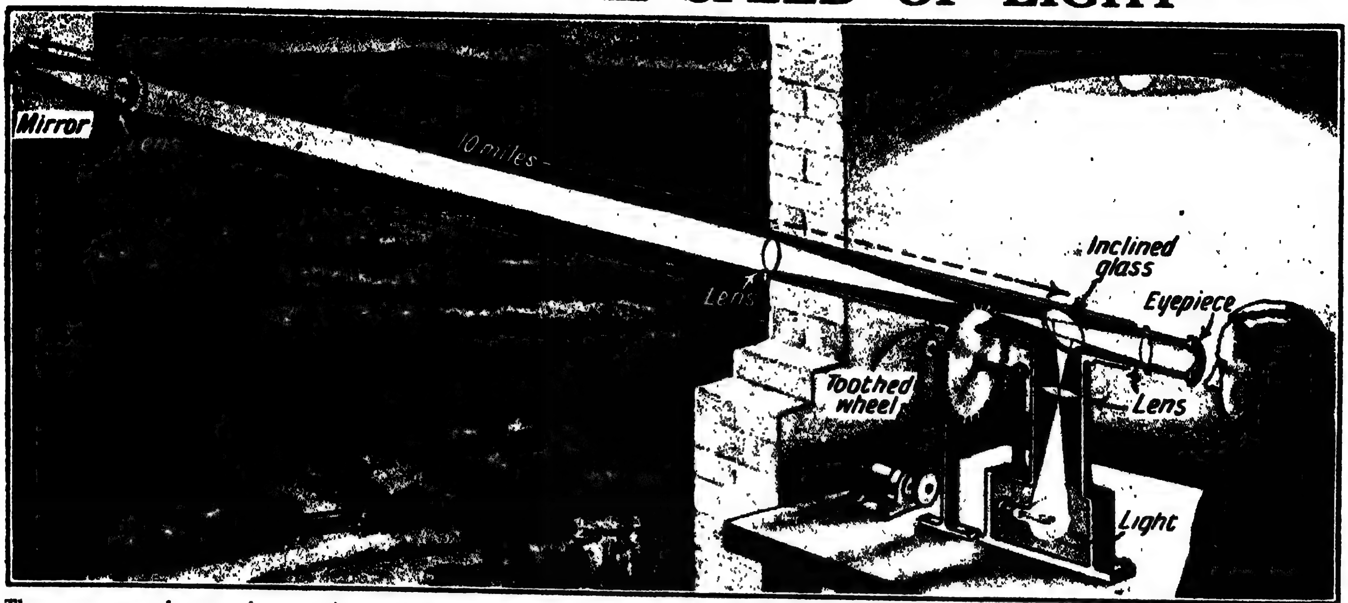


A cornet consists of a tube widened out at one end and narrowed towards the other extremity. To make the instrument convenient for handling the tube is bent to and fro. A note is produced not by blowing hard, but by vibrating the lips and setting the air in the instrument also vibrating. The different notes are obtained by varying the length of the tube, and this is done by means of keys which move pistons and link up different sections of the tube. In the top picture the air is vibrated round the bent tube through B, and then conducted by channels as indicated by the arrows to A, and so out. To cause the air to vibrate in a longer tube and give a different note, as in the left-hand bottom picture, the extension C (cut away in the top picture to show B clearly) is utilised, by pressing down the first piston. The air vibrations now pass from B round into C, before going into A, and out through the cone. In the third picture, by depressing the first and third pistons, the air vibrations travel through B and C and D and E before going through A and out at the cone



The trombone is a much simpler instrument than the cornet, for it has no pistons, and the different lengths of tube for the different notes are obtained by sliding one part of the instrument up and down, thus adding to or shortening the length. In the upper picture the instrument is closed, giving the shortest length of tube, and below it is fully extended, thereby almost doubling its length

MEASURING THE SPEED OF LIGHT



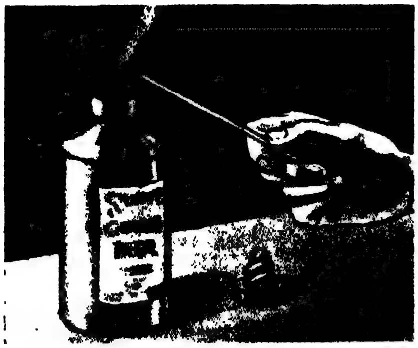
There are several ways of measuring the speed of light, and here is one. A bright light concentrated by a lens is reflected by an inclined mirror to a distance of several miles, where the beam is caught by another lens and focussed on a concave mirror. A scientist watches this reflection through a telescope, in front of which rotates a toothed wheel. When this moves at a certain speed the distant light is seen between the teeth, but when the wheel's speed is increased the light is intercepted by the teeth. Knowing the time required for one tooth to move through a certain distance, the speed of the light intercepted by the tooth can be worked out. It is 186,000 miles a second

THE WAY IN WHICH A ROOM IS VENTILATED

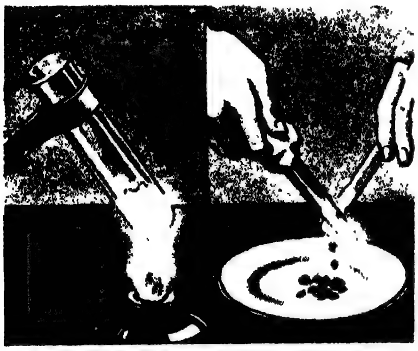
This picture shows how the circulation of air in a room is kept up. Warm air always rises, and so the gases we breathe out and the air that is warmed by the fire rise, as shown by the arrows, and pass out through the top of the door. The cooler fresh air enters by the window and door, and, being heavier, remains in the lower part of the room till it is warmed and rises, cold air again rushing in to take its place. Thus a constant circulation is kept up. A lighted candle against a keyhole shows that air is passing through

EXPERIMENTS WITH HOME CHEMICALS

It is not necessary to lay in a big stock of out-of-the-way chemicals to perform interesting and instructive experiments. There are



An experiment with ginger beer



Combining iron and sulphur

plenty of substances in our homes with which we can experiment and learn important scientific facts.

Take, for instance, such a familiar article as a bottle of ginger beer, or soda water. As we know, the liquid contains a great deal of gas, the same gas that is found in lemonade, and other fizzy mineral waters. It is known to chemists as carbon-dioxide. This is the gas that we breathe out, and it does not support life or combustion. If we were placed in a room full of carbon-dioxide we should die, and when we are in a closed up room containing a large number of people, we soon get drowsy. This is because the air has become laden with the carbon-dioxide gas breathed out by the crowd.

We can prove that carbon-dioxide gas does not support combustion, by holding a lighted taper to the mouth of a ginger beer or soda water bottle. The moment we uncork it the gas begins to escape and the flame is put out.

Here is an experiment to show how two elements combine to form a chemical compound. Take an ordinary glass test tube, and put in it a few clean iron filings and some flowers of sulphur. Shake them together and then hold the test tube over a spirit lamp or gas ring. At a certain temperature the iron and sulphur will combine and produce iron sulphide.

Another way to perform the experiment is to make a rod of iron white hot in the fire, and then while it is in this condition touch a stick of brimstone. The iron and brimstone, which is sulphur, combine, and the iron sulphide drops down, the metal rod apparently melting away like sealing wax. Of course, we must be careful where we perform such experiments, doing them over a hearth or stone floor.

Washing soda is kept in every house, and when we look at this material we may not think that it contains metal, but one of the elements of which it is made up is the metal sodium, and we can prove this by taking a steel wire, dipping it into a strong solution of soda, and then holding the wire in the flame of a gas ring.

We see a rich golden flame which is the metal sodium in the soda solution burning.

An amusing experiment which looks like a conjuring trick can be performed before our friends to mystify them. We call it "changing wine into water."

We take a few crystals of permanganate of potash, and dissolve them in a glass of water. Then we pour into the coloured fluid a few drops of oil of

Watching the metal in soda burn

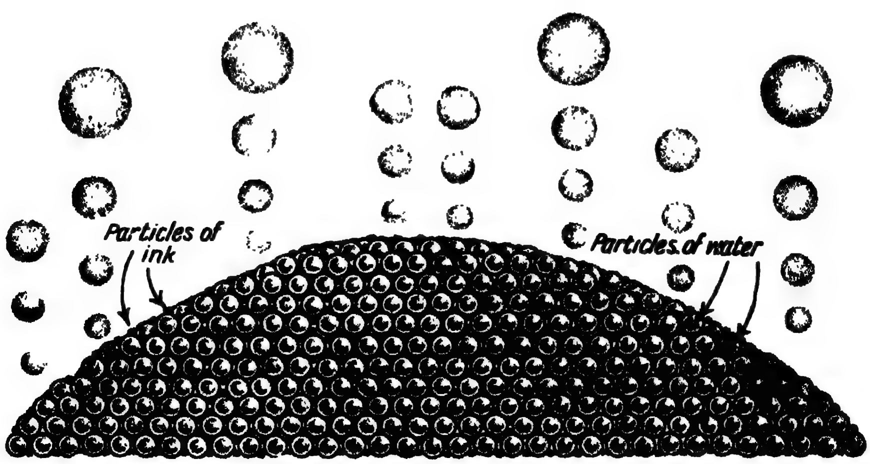
A mystifying experiment for a party

vitriol or sulphuric acid. The liquid now looks like red wine, but if we pour into it a little hyposulphite of soda, known to photographers as "hypo," the colour at once disappears and the glass appears to contain water.

Chemical action has taken place, breaking up the permanganate of potash and the sulphuric acid, and forming sulphate of potash and sulphate of manganese, both colourless.

HOW AN INK BLOT DRIES UP AND LEAVES A STAIN

The black inks we use for writing are made from water and tannate of iron, a substance that darkens on exposure to the air. When we drop a blot on our paper from the pen and leave it we find after a time that the blot is dry but the paper is stained black. What has happened is shown in the accompanying picture. The dark part of the ink consists of little particles, and these are mixed with particles of water, forming a black liquid. The



An ink blot drying. The water escapes leaving the solid black matter behind

particles of ink will not evaporate, but the water evaporates, rising in little invisible globules of vapour which expand with the heat as they rise and mingle with the atmosphere round about. At last all the water is driven off and only the particles of stain are left on the paper. In the liquid state the little particles of ink are held buoyed up between the particles of water.

Of course, the warmer the air the quicker the blot of ink will become dry

WHY THINGS DO NOT FALL APART

We can hold up a slab of marble, but we cannot hold up a slab of sand. Directly we try to lift a piece of sand the grains all fall apart. Why is this? A force which men of science call Cohesion holds the particles of a substance together, but its power varies greatly in different materials. Even grains of sand can be made to cohere to some extent when they are wet. The word "cohesion" means "a sticking together." Here we read some facts about this remarkable force, which is of great value to mankind

HAVE you ever thought what a remarkable thing it is that when two teams of extremely powerful men are pulling the ends of a comparatively slender rope, the rope does not break?

You may also see a huge liner towed through the water by means of a slender steel hawser. The strain on this cable must be enormous, yet it does not break. On the other hand, sometimes when you are tying up a parcel and you pull the string tightly it breaks. Why is this?

Why is it that so rarely does a rope break, or cloth tear, or wire snap or a wooden plank give way? Why is it that sometimes when you catch your umbrella in a crack or hole in the pavement the stick snaps, and why is it that a stout poker which when it is cold will not bend at all, can be bent quite easily when it is made red-hot in the fire? Why, too, if you drop a kettle on the stone floor of the scullery, does it dent but not break, and why if you drop an earthenware basin or china cup does it crack or break up into fragments?

A Clinging Force

All these facts are very commonplace, and yet there is a reason why the different objects and materials behave in the different ways described. There must be some force or power which holds the particles of a substance together, and that force is known to science as Cohesion.

The name comes from a Latin word which means "to cling together," and cohesion is the force which causes the molecules of a body to hold together.

The power of cohesion in different substances varies a great deal, and the strength of a material depends upon whether the force which holds its particles together is strong or weak. If we take a biscuit between our fingers we can break it quite easily, for the cohesion between its various particles is very weak indeed. But if we take a penny between our fingers we shall find we can make no impression, the reason being that the cohesion between the molecules is powerful.

Before the force of cohesion can come into play the molecules must be very close together. If we smash an earthenware or porcelain pot we may fit the fragments together so skilfully that the unaided eye can detect no cracks at all, but we have only to touch the vessel with our finger for it to fall to pieces again. The cohesion between the molecules has been destroyed, and though when the fragments are fitted together they appear to be very close, they are not close enough for cohesion to come into play.

There are some substances, however, which can be welded together by cohesion much more easily than others. If, for example, we take two slabs of lead with very smooth, level and clean surfaces, and press them tightly together with a screwing motion, they will cohere so that a good deal of force is required to pull them apart again.

Similarly, if two very smooth cast-iron plates are pressed together so as to exclude the air between them, they will adhere so firmly that they will support a considerable weight. This is in no sense due to atmospheric pressure, as in the case of a boy's sucker, for they will adhere just as firmly in a vacuum.

Powdered graphite, that is the material which forms the lead of lead pencils, when subjected to a very great pressure, becomes a solid mass. The pressure brings the mysterious force of cohesion into play, and the particles hold together. This force is also present in liquids, though there it is much weaker than in solids. If we take a perfectly clean glass rod and dip it into water, we shall find when we withdraw it that a film of water clings to the rod. If, on the other hand, we dip the glass rod into quicksilver, none of the metal adheres.

Cohesion Lessened by Heat

This shows that the force of cohesion is stronger between the glass and the water than between the molecules of water themselves; and, on the other hand, there is no cohesion at all between the quicksilver and the glass. The tenacity of wire is due to the cohesion between its molecules, but the cohesion of solids is very much lessened by heat.

The older scientists used to make a distinction between the force which holds together the particles of one particular material or body and the force which holds together two different kinds of particles; they called the former cohesion and the latter adhesion. Thus, they said, the molecules of a plank of wood were held together by cohesion, while if the plank were glued to another plank the glue and the wood held together by adhesion.

In the same way the particles of a stick of chalk were, they said, held together by cohesion, while when writing was put upon the blackboard it was adhesion that held the chalk and the board together.

This is the famous Portland Vase, which was smashed into many fragments by a madman at the British Museum. The cohesion between the particles was overcome, but the many pieces were fastened together by cement and cohesion was once more restored by its means

Modern scientists, however, make no such distinction, but speak of cohesion in all cases.

What exactly is the nature of this mysterious force, scientists are unable to say definitely. They think, however, that it is electro-magnetic in its origin.

If the force of cohesion were suddenly to cease, everything in the world would collapse. Houses would fall, furniture would become heaps of powder, and indeed all solids would be reduced to tiny particles. When in the engineer's shop metals are soldered, brazed or welded together, the strength of the joint depends entirely on the force of cohesion.

When engineers and builders speak of the strength of materials they are really only speaking of the force of cohesion which is operating among their particles. Many of the physical properties in which solid substances differ from one another depend on the differences in the cohesive forces which exist between their molecules. Hardness, brittleness, ductility (that is, the extent to which a substance can be drawn out into wire), malleability, or the extent to which it can be hammered into thin sheets, tenacity, or its power of resisting breakage, and elasticity, or the ability of a body after being drawn or pressed out of shape to return to its original condition, all depend on this force of cohesion.

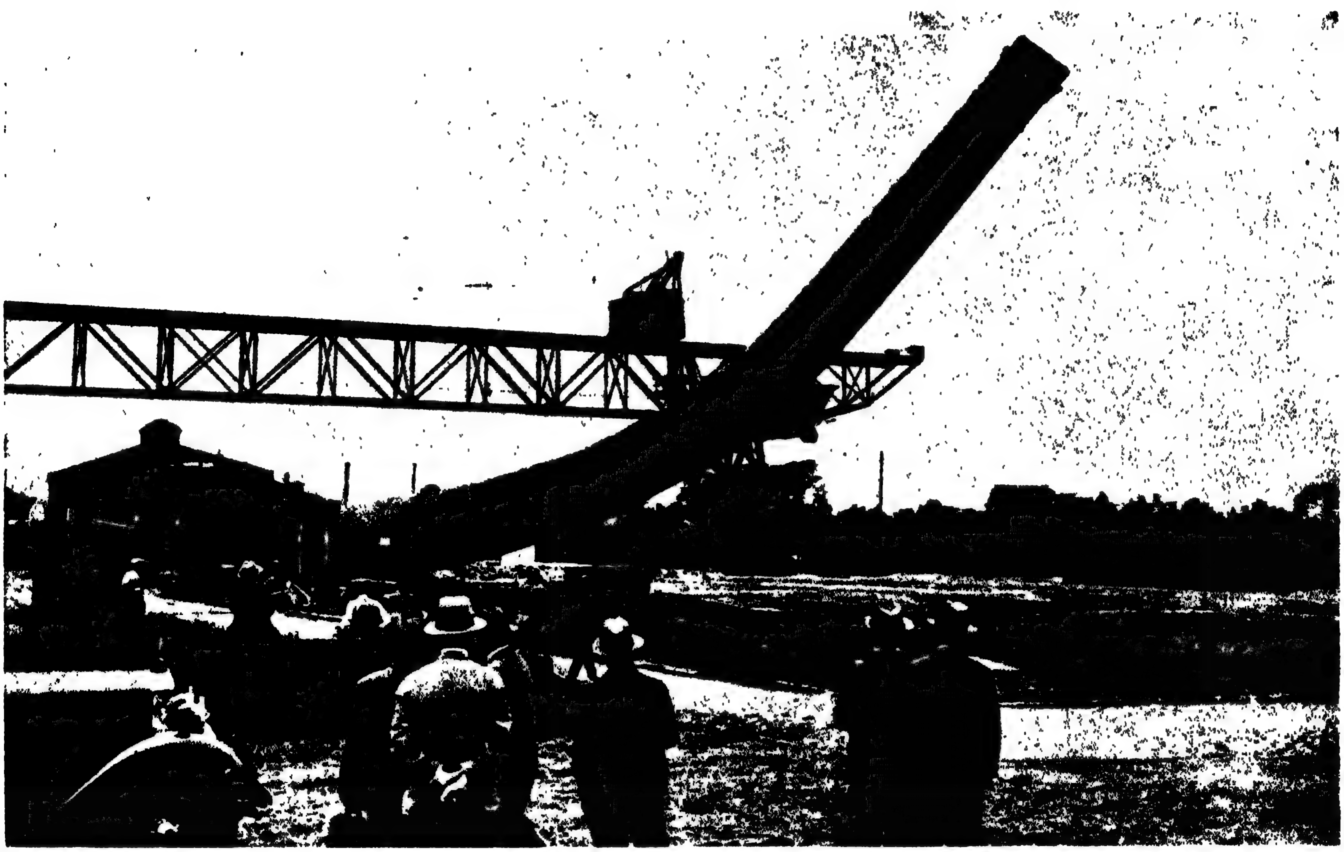
With regard to malleability, it is interesting to know that gold, which is the most malleable of all substances, has been hammered into sheets one-300,000th of an inch in thickness—that is, sheets so thin that it would take 300,000 piled one on top of another to make up an inch.

An interesting object-lesson in cohesion is afforded by the famous Portland Vase. This work of art, which is made of beautiful dark blue glass with figures of opaque white glass decorating its outside, and was found in the sixteenth century in a marble sarcophagus near Rome, is supposed to be about 2,000 years old.

For more than a century it was the glory of the Barberini palace in Rome, and was called the Barberini Vase. Then, after changing hands several times, it came into the possession of the Duke of Portland, since when it has been known as the Portland Vase.

While it was on loan in the British Museum a strange thing happened. On February 7th, 1845, just before closing-time, a loud crash was heard, and when attendants rushed to the spot they found the beautiful vase lying in fragments on the floor. A madman had hurled it to the ground. The shock of striking the floor had overcome the cohesion between the particles of the glass, and never again could the Portland Vase be as it had been.

But an employee of the Museum, with infinite patience and remarkable skill, stuck the pieces together again, so that the vase is able to stand up. At a distance it is almost impossible to see where the fragments are joined, and no doubt the cohesion between the glass and the cement which holds the pieces is probably as great as between the molecules of glass themselves. But the cement is necessary. No amount of pressing the fragments together without cement can produce the necessary cohesion to make the vase a unit.

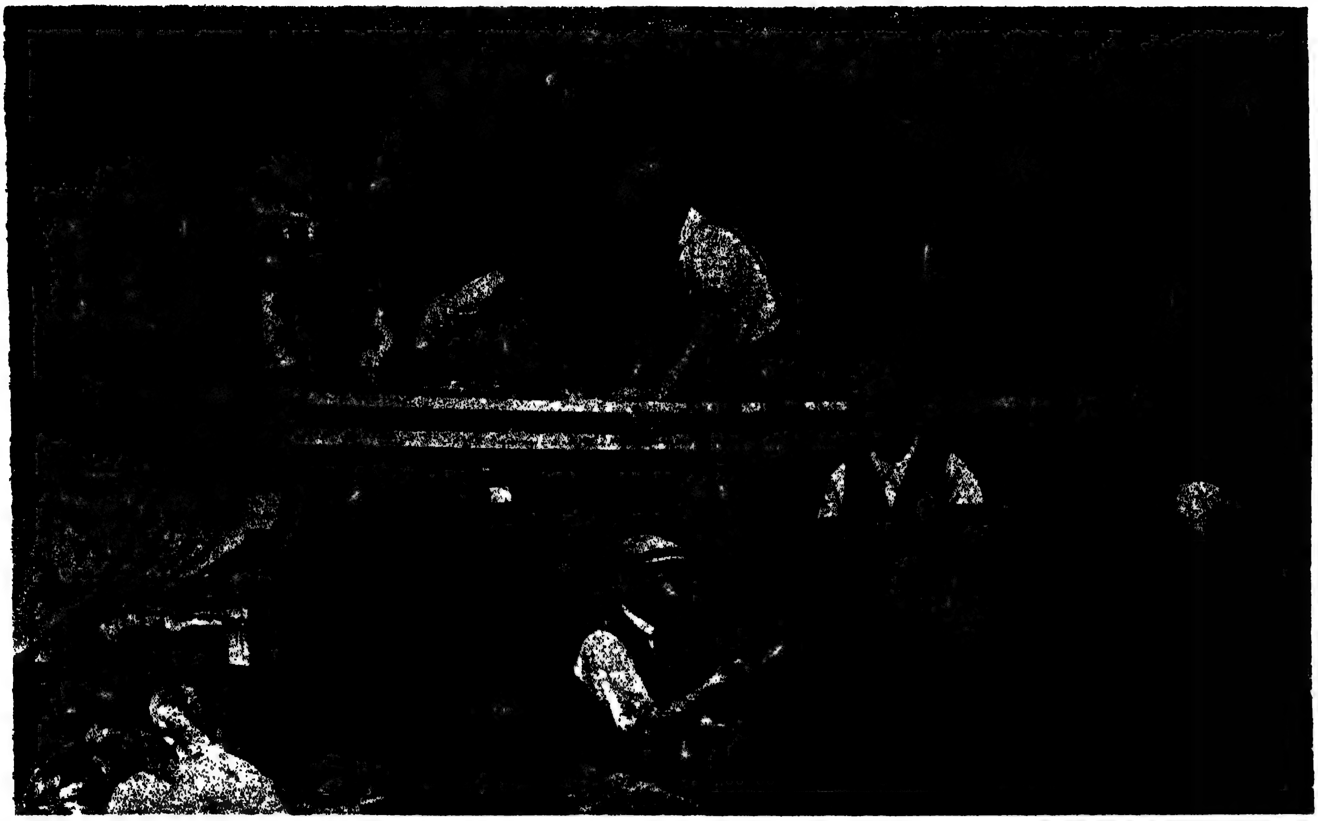


We often see examples of the force of cohesion being overcome by some other force, as when the pressure of our fingers breaks a biscuit in two, or when we drop a plate and break it. Here is a striking illustration of this. A chimney which has stood for half a century is seen being felled. One side was undermined, and the force of gravity caused it to begin to fall. Then the wrench given to the different parts of the chimney falling at different speeds overcame the cohesion between the bricks and mortar, and it broke up

When a tall factory chimney that is no longer wanted is felled, it begins to fall as one structure till the wrench and the varying speeds at which the different parts of the chimney fall overcome the cohesion between the bricks and mortar and the chimney begins to break up into fragments, as can be seen in the picture on this page.

It has been said that heat weakens cohesion. That is why a red-hot poker can be bent so easily, and a piece of wire which when cold supports a certain weight, will break under the same weight if the wire be heated.

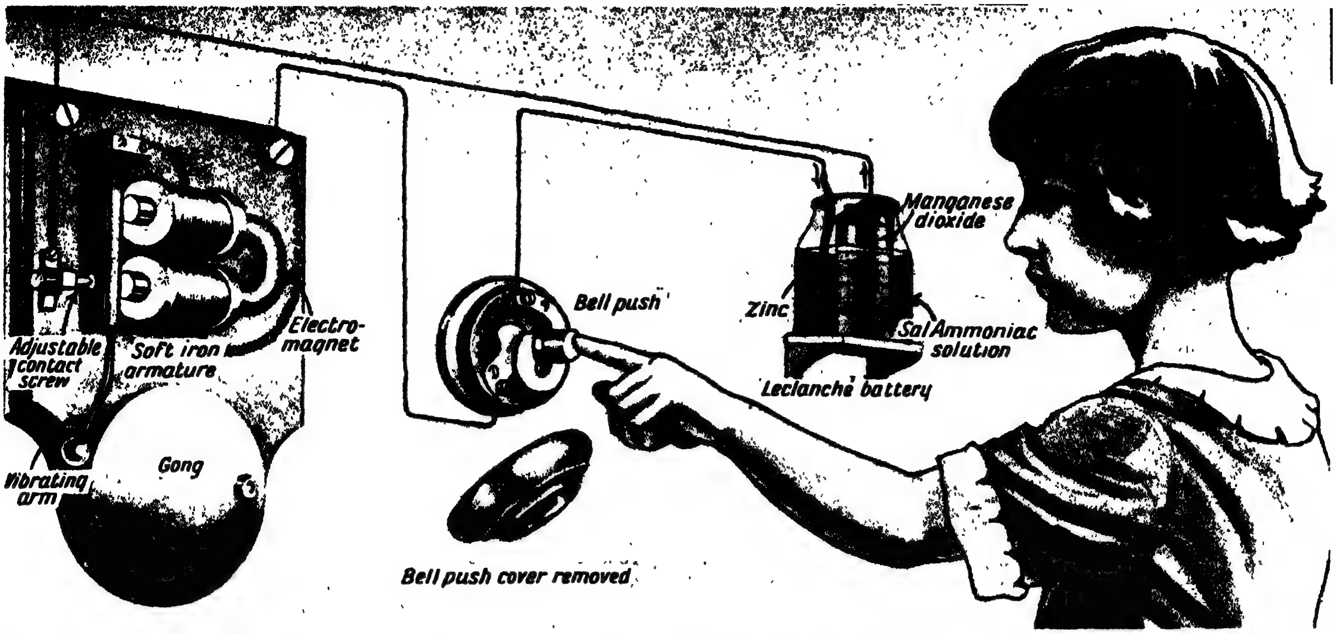
EXAMPLES OF THE FORCE OF COHESION



The force of cohesion, which holds things together, is the force which enables us to build houses and churches and chimneys by piling brick on brick. The power of cohesion between different materials varies a great deal. There is very little cohesion between the bricks themselves, but by using mortar we are able to build a wall that will stand for a hundred years or more. Indeed, some buildings put up by the Romans and others have stood for thousands of years

Here is still a more striking example of cohesion. A rope is made up of short lengths of fibre twisted together, and it is the cohesion that makes the rope so strong that when a number of muscular men are pulling on the rope in opposite directions, as in a tug-of-war, the rope holds together without parting. Of course, if more and more force were used this might at last overcome the power of cohesion and the rope break. This sometimes happens with a ship's cable when wind and waves put an extra strain upon the rope. Friction between the various strands of the rope also has something to do with holding it together

HOW AN ELECTRIC BELL IS MADE TO RING



The bell-push has a button fitted to a spring which, except when pressed, stands away from the other metal of the push. Wires connect up the battery with an electro-magnet and with the bell-push. As long as the push is untouched the electric circuit is broken, but as soon as the button is pressed the electric circuit is completed. A current now flows from the carbon or positive pole of the battery to a contact screw, passes up a steel spring to which a soft iron armature is attached, goes round the coils of the magnet, back to the bell-push, through the spring and the wire attached to it, and thence to the zinc or negative pole of the battery. The current going round the coils of the iron horseshoe turns that into a magnet, the armature is attracted and pulls the spring, vibrating a hammer and causing it to strike a gong. As soon as the armature and spring are drawn to the magnet away from the contact screw, the electric circuit is broken, whereupon the horseshoe ceases to be a magnet and the spring returns to the contact screw. At once the current is re-established, and the same thing happens again and again so long as the button is pushed

WHY A WHIP CRACKS WHEN IT IS SLASHED

When a whip with a long lash is slashed right and left with a swing, we hear a loud crack. What causes this? Well, as the thong of the whip moves through the air at a rapid rate it compresses the air before it and then the compressed air, as soon as the lash has gone, expands back and resumes its normal pressure as suddenly as it was compressed.

Making an explosion with a whip-lash

It is when the air is expanding to return to its place that it sets up a movement in the molecules of the atmosphere, causing them to strike upon our eardrums, and the auditory nerve then carries the message to the brain.

The crack of the whip is really a miniature explosion, the compressed air expanding suddenly making the same kind of sound as an explosion of, say, gunpowder.

A cracking sound is generally, if not always, the result of a small explosion. We get a familiar example of this in the crackling of a wood fire when it is lighted.

We know how, as soon as the paper has set light to the wood, there is a regular series of cracks. These are actually little explosions taking place in the wood.

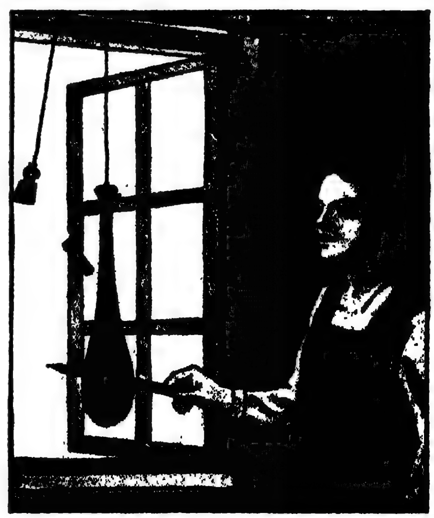
The cavities are filled with air or liquid, and the heat causes this to expand suddenly with the result that there is an explosion setting up waves in the air which reach our ear-drums in the same way as in the case of the cracking of a whip-lash.

The sharp crack of thunder which is heard, when we are very near the lightning, is also caused in the same way. As the lightning, which is an electric spark on an enormously large scale, passes through the air its heat causes a sudden expansion of the air in its track, and this is succeeded almost immediately by a sudden compression of the air round the path of the lightning, with the result that there is a rapid inrush of air particles to fill the vacuum thus caused. In other words, there has been a kind of explosion giving the cracking sound which we know as a thunder clap.

STORED UP ENERGY CHANGED INTO MOTION

We can perform an interesting experiment by hanging an Indian club and a small weight from a beam. The strings must be of such a length that the two objects will swing in unison. Set both swinging, then stop the Indian club.

Now with a pencil give the club gentle taps near its centre of gravity, timing them by the swing of the small weight. There should be one tap for each double swing of the weight. Gradually the stored up energy received from the light pencil taps will set the club swinging once more.



How to tap the swinging club

WONDERS of ANIMAL & PLANT LIFE

THE STREAM OF LIFE IN YOUR BODY

Except when we cut a finger or our nose bleeds, we rarely give a thought to the blood that courses through our bodies. Yet it is the most important substance in the world, and if we lose it, or it should stop travelling through our arteries and veins, we should die. It is indeed our very life-stream and in these pages we learn much about its nature and its importance to us

MEN of science have studied the blood for centuries, and have found out a great deal about it, but even now they have much to learn and there are many things about our blood which cannot be explained.

The blood does a vast amount of work in our bodies. It carries to the various tissues food-stuffs that have been properly prepared by our digestive organs; it also carries to the tissues oxygen gas which has been absorbed from the air in the lungs; and it carries off from the tissues various waste products which must be got rid of. It also helps to equalise the temperature and the water contents of different parts of the body. All this shows how important the blood must be to our life and health.

What is this wonderful fluid upon which we are so dependent? Well, when it is examined it is found to consist of various parts There is, for instance, a liquid part called by men of science plasma, and this is nearly colourless, although as we know when we prick our finger the blood is red, sometimes bright red, and sometimes much darker. It is bright red if it is fairly pure and comes from an artery, and it is dark if it is impure and comes from a vein

Tiny Discs

But what gives the blood its red colour if the liquid part of it is nearly colourless? Well, in the plasma there float a great number of tiny discs known as red corpuscles. They are not really red, but a kind of deep yellow. When, however, numbers of them are seen together they give the impression of redness. They are very small indeed. A red corpuscle is only one 3,200th of an inch in diameter, and in thickness about one-third of this. That is, if laid side by side it would take 3,200 red corpuscles to measure an inch, and if packed together like pennies piled up it would take nearly 10,000 to make an inch. If we laid red corpuscles side by side it would take about 10,000,000 of them to cover one square inch.

About half the weight of the total amount of blood in our bodies consists of red corpuscles, so knowing how small they are we can quite understand that there must be an enormous number. Indeed, in every cubic inch of blood in our bodies there are about 82,000 million red corpuscles, and in the whole of the body of a full-grown man weighing eleven stones, the number is about 25 million million. What a marvellous thought it is that we have in a thimbleful of our blood more than thirty times as many corpuscles as there are people in the world.

An Amazing Fact

Now it is these little bodies which absorb the oxygen from the air as they pass through our lungs, and as we need a great amount of oxygen it is a very good thing there are so many tiny red corpuscles, for the total number present a very large surface to the oxygen. The total area of all the red corpuscles in a man's body is nearly 35,000 square feet, or 1500 times the whole of the outside surface of his body What an amazing fact this is

If we go up a mountain our blood soon has an increasing number of red corpuscles, and at a height of 13,000 feet we should have nearly half as many again as when we are at sea level This is a wonderful provision of nature in order that our bodies may receive sufficient oxygen

As we know, at the top of a high mountain the air is much rarer than it is at sea-level, which means that it contains much less oxygen. Our blood, therefore, at such a height develops more and more red corpuscles, so that their area or surface may be greatly increased and thereby be enabled to take up as much as possible of the oxygen that gets into our lungs.

But the red corpuscles are not the only bodies which are found in the plasma or liquid of the blood There are some other corpuscles which are white in colour and are, in consequence, known as white corpuscles.

They are larger than the red corpuscles, being one 2,500th of an inch in diameter. They also differ from the others in being not round like discs, but irregular in form They are all sorts of shapes and, something like that little creature known as the amoeba, are constantly changing in shape. Men of science are not quite sure whether there are different kinds of white corpuscles or whether their apparent differences are due only to these constant changes in form

Another way in which white corpuscles differ from the red is that there are far fewer of them in the blood; in fact, on an average there is only one white corpuscle to every 500 red. They are like the red corpuscles, however, in that the number varies at different times. It increases during digestion, and so, while at one time there may be one to every 300 red corpuscles, the proportion may be only one to every 600 at another time

These three pictures show in diagram form what happens to our blood if it is taken from our body. The fresh blood has just been placed in the first glass, and the red and white corpuscles are floating in the fluid. Almost directly, however, chemical changes take place, and small fibres form as in the second glass. After about ten minutes these, with the corpuscles, form a solid mass known as a clot, and the fluid part becomes a thin, watery liquid called serum

Disease Fighters

What is the work of these white corpuscles? Well, doctors are still studying them and they do not yet know everything the white corpuscles do to help our bodies, but they know that they are of enormous service in fighting disease

If we get a wound and inflammation sets in, white corpuscles rush to the spot and begin devouring or absorbing the injured tissue, which is causing the harm, or the little bacteria that cause the trouble. In other words, they help us to resist infection. They are like a great and efficient army of defence in a country; directly an enemy invades the country the army of defence rushes to the spot to repel the invader.

So it is with the white corpuscles of our blood. They lose no time in assembling at the danger spot and generally they win the battle, though

sometimes the invading army of bacteria is too strong for them.

They fight the enemy by eating him up. They also clear away dead tissue, whether it be due to injury or to any other cause, and in the case of the tadpole, when its tail becomes no longer necessary, it is by means of the white corpuscles in the blood that the tail is absorbed as the tadpole changes into a frog. By a wonderful provision of nature in certain acute diseases the number of white blood corpuscles is greatly increased. It is indeed like the mobilisation of a fighting army from the civilian population of a country when invasion threatens.

In addition to the red and white corpuscles there is a third class of bodies in the blood known as blood plates or platelets. They are so small—much smaller than the red corpuscles—that it is only in recent years that they have been discovered at all, and their minute size makes examination exceedingly difficult. Indeed, some scientists deny the existence of these plates altogether.

Hidden Wonders

Their number has been variously estimated at from 3,000 million to over 13,000 million in every cubic inch of blood. Their shape is said to vary a good deal, some being doubly convex on both sides like a lens, and others flat like a gramophone record. They are believed to have something to do with forming clots of blood, as they always gather round any injured spot in the wall of a blood vessel and fuse together so as to form a clot over the injured place, thereby preventing the escape of blood from the blood vessels. They are believed to exist only in the blood of mammals.

To return to the red corpuscles, these are being constantly formed in the blood, and it is, therefore, assumed that they are also being constantly destroyed. They are soft, flexible, elastic bodies, so that they can readily squeeze their way through openings and canals narrower than themselves without undergoing any permanent change of shape.

When we lose blood, and we must remember that one-thirteenth of the weight of our body consists of blood, though the proportion in a new-born baby is only one-nineteenth, nature at once begins to make up for the loss. First of all the fluid parts of the blood are made up so that the total volume is restored to its normal, but then, of course, there is a shortage of red corpuscles. Gradually, however, their number is increased, until in a few weeks the blood is normal once more.

New red corpuscles are said to be formed in the marrow of our bones, where the blood capillaries and veins have very thin walls. It is there that the newly formed corpuscles are able to pass through the walls into the blood stream.

Each red corpuscle consists of a framework of protein, containing in its meshes a red colouring matter known as haemoglobin, and it is to this that the red colour of the blood is due.

This picture shows what happens when we cut or prick our finger. The blood would continue to pour out, but directly it reaches the air chemical changes take place, and fibres are formed which are known collectively as fibrin. These bind together the corpuscles and the fluid, which all hardens into a clot that stops up the opening and prevents further blood from escaping

Haemoglobin has the power of uniting with considerable quantities of oxygen gas, and it thus gives the red corpuscles their useful power of acting as the carriers of oxygen from the lungs to the tissues in all parts of the body.

The haemoglobin or colouring matter of the red corpuscles forms crystals, and these vary in shape according to the animal from which the blood is taken. In man they have the shape of prisms. Haemoglobin from human blood crystallises less easily than that from the blood of other animals.

There is one property of blood which is of the very greatest value to us, and that is its power of clotting or becoming solid and jelly-like. We know how when we cut or prick our finger the wound bleeds for a short time, but soon the blood becomes solid round the cut, filling up the gap, and then the bleeding stops.

Let us see why the blood clots. It is certainly one of the most marvellous provisions of nature for saving us from bleeding to death. The plasma or liquid part of the blood in which the corpuscles move contains in solution various protein substances. One of these is known as fibrinogen. When the blood escapes from a blood vessel this fibrinogen undergoes certain chemical changes, and produces little threads or fibres which are called by men of science, fibrin. It is these which cause the clotting of the blood. In fact, the clots consist of these fibres massed together.

Of course, the wonderful thing is that the blood does not clot in the arteries and veins; if it did the stream would cease to flow, and we should die. But directly there is a wound in a blood vessel and the blood begins to pour out, the chemical changes take place, fibrin is produced, and the wound is stopped up so that no more blood can get away.

The Bundle of Fibres

When the fibres are formed a yellowish, watery-looking fluid is left and appears on the surface of the clot. This is called serum. The clot of fibres has the corpuscles of the blood mixed with it. It is interesting to know that if blood freshly taken from the body is "whipped" in a vessel with twigs, just as we whip cream, the fibrin collects on the twigs, and a red fluid is left in the vessel consisting of serum with red and white corpuscles. The corpuscles in that case, do not get mixed up with the fibrin as they do in a clot. When the fibrin is washed in water it is found to consist of a white, stringy, elastic substance. Heat hastens clotting, and cold retards it.

Of the pumping of the blood through the body and the wonderful machinery that does this work we read in another part of this book, but next time we prick our finger and see the red blood, let us remember what a very marvellous substance it is and how our life and health and happiness all depend absolutely upon it.

A GREAT BATTLE IN THE BLOOD

Sometimes when we have a wound, dangerous germs from outside try to enter our blood, and if they succeed we get ill. But if we are healthy we resist the germs. This picture shows the kind of thing that goes on when the germs try to enter. A great battle takes place. Little bodies in the blood, known as white corpuscles, rush to the opening to resist the germs. Generally they absorb and destroy them, but sometimes the germs get the upper hand, defeat the white corpuscles, and destroy them. Then they run riot in the blood

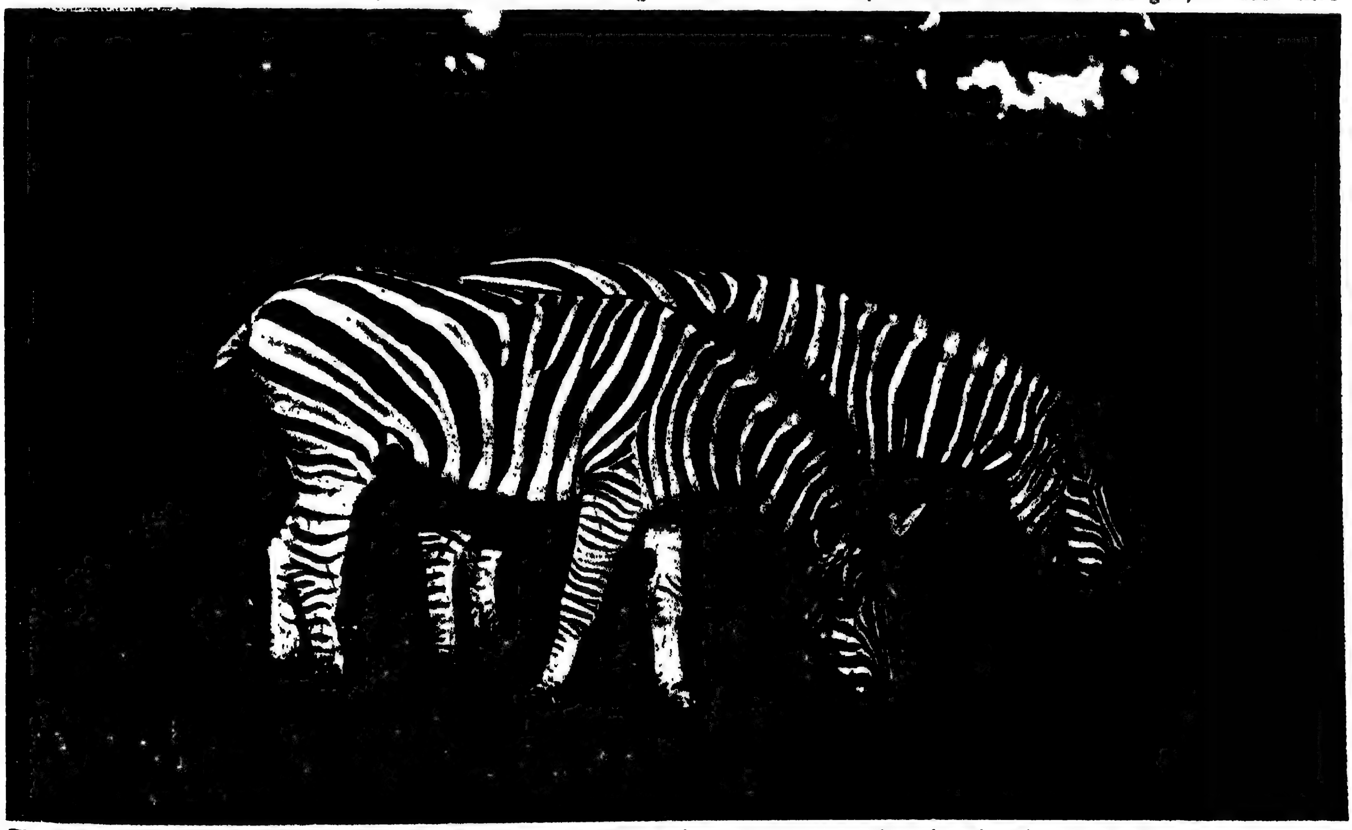
The attack of the disease germs on our body is very much like the attack of troops on a city or fort. They try to rush the place as they are doing in this picture, but the defenders hurry up to keep them out, and sometimes one force may win and sometimes the other

THE MANY DIFFERENT SHAPES OF LEAVES

Leaves are a very important part of a plant, for it is by means of them that it breathes and takes in carbon dioxide and oxygen from the air. Leaves vary much in form and texture. We know that a grass leaf is a long blade and a nasturtium leaf almost round. Some leaves present an unbroken surface, while others are indented. The different kinds of leaves are grouped according to shape, and botanists have given them special names. On this page we see 52 leaves, with the correct names given to their particular forms. Some names are from Latin words, like Digitate, from digitus, meaning a finger. Others have formidable names like Quinquangular, which means having five angles. The separate parts of divided leaves, though looking like individual leaves, are only leaflets or parts of the one leaf

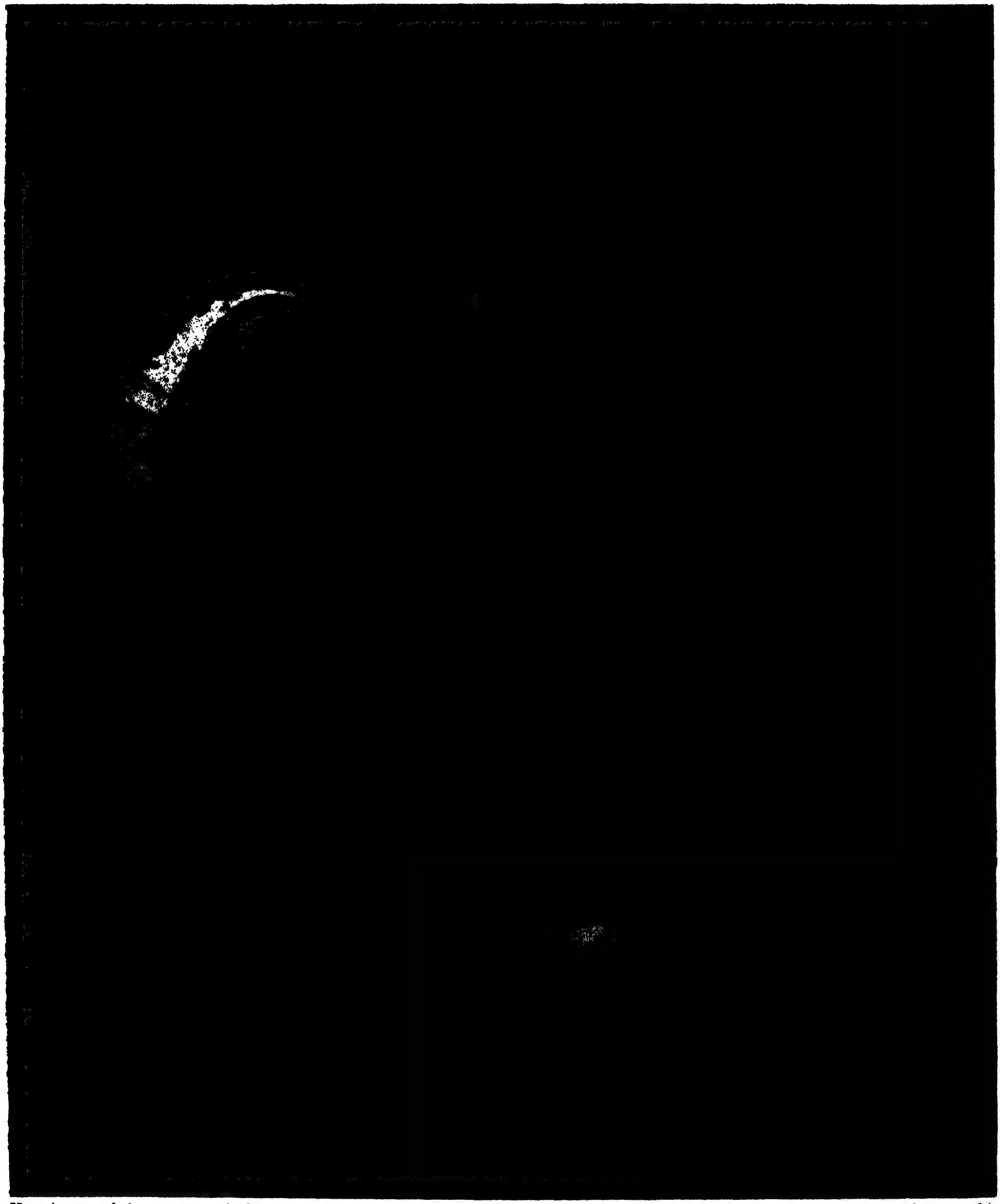
THE ZEBRA OF THE AFRICAN PLAINS

The zebra, of which there are several species, varying in their striping, is a South African animal, and though one species, known as the quagga, became extinct in 1875, other zebras are still quite plentiful. These animals, close relations of the horse and the ass, are dwellers in the open plains, and they are often found in large numbers associating at water holes with the gnu, as seen here



The zebra is a very striking animal, and men of science are not quite sure why nature has given it stripes, for, unlike the tiger, it does not live among the tall grasses where its stripes would look like shadows in the sun, and so conceal its presence. A few zebras have been broken to harness, but the animal has never been bred for domestic uses. Perhaps it might become as useful as the horse

AN AMAZING FLAME 350,000 MILES LONG



Here is one of the most wonderful photographs ever taken. It shows the Sun during a total eclipse, but the marvellous feature of it is the white object, something like an ant-eater in shape, at the top left-hand. Because of its shape astronomers call this the "Ant-eater Prominence." It is really an inconceivably enormous crimson flame shot up from the Sun's surface at a speed of thousands of miles a minute. The flame when first seen, as in this photograph, was 350,000 miles from end to end—an "ant-eater" which, as Sir James Jeans has said, could gulp down the whole Earth like a pill. The moment after this photograph was taken the flame made a great leap to a height of 475,000 miles. It is an amazing thought that astronomers watching gigantic flames of this kind sometimes see them travel at the rate of 8,000 miles a minute. The photograph is published by courtesy of the Royal Astronomical Society

THE GLOWING BALL OF FIRE IN THE SKY

It is hardly surprising that in past ages, when knowledge was dim, men worshipped the Sun, believing it to be a god. They realised that they received light and warmth from its genial rays, and knew that in some way they depended for their lives and hea'th upon its continued shining. In these days we know that the Sun is not a god, although we are dependent upon it for our existence. Let us see what the Sun really is.

HERE we read many surprising facts about the Sun. The Sun is a ball of fire, but not fire as we understand it, for there is no burning going on, that is, no chemical combination between oxygen and other elements. Everything in the Sun is too hot to burn in our familiar sense of the word. Men of science tell us that the temperature of the Sun at its surface is about 7,000 degrees Centigrade, or 12,000 degrees Fahrenheit. The highest temperature we can obtain artificially on the Earth is that of the electric arc, about 4,000 degrees Centigrade.

But this great temperature is only that of the Sun's surface. Deep down the temperature rises enormously, and Sir Arthur Eddington, the famous Cambridge scientist, believes that at the centre it is as high as 55 million degrees Centigrade.

Inconceivable Heat

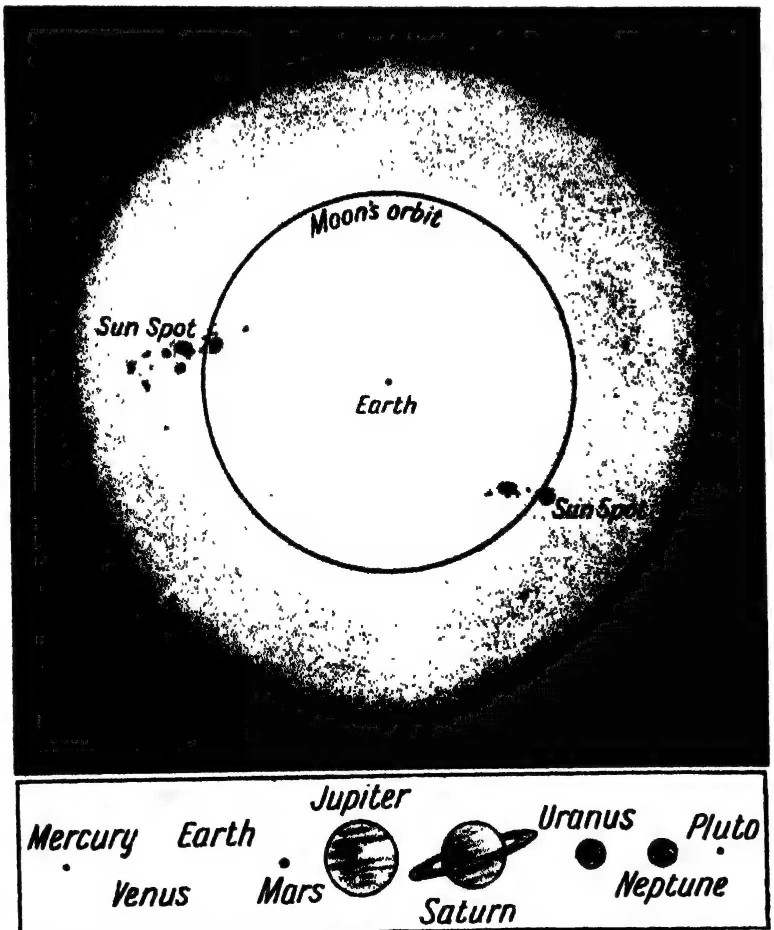
Of course it is impossible for us to conceive any such heat but Sir James Jeans tries to help us by explaining that to maintain a pinhead of matter at such a temperature would need all the energy generated by an engine of 3,000 million million horse-power, and then the pinhead would emit enough heat to kill anyone within a thousand miles of it.

With so much heat the state of matter in the Sun is very different from what it is on our Earth. It is all in a gaseous condition, although the enormous pressure towards the centre must cause it to be very dense. The heat is so terrific that chemical compounds cannot exist, and even the atoms of the elements are in many cases broken up.

The Sun does not keep its heat to itself, but pours it out in all directions. But of this heat the Earth receives only about one 2,200 millionth. Altogether in the solar system it is reckoned that about one hundred millionth of the heat radiated by the Sun is caught by the planets.

Let us see if we can get some idea of the enormous power of the Sun's heat. Supposing that the Sun's surface were frozen over to a depth of 45 feet, the heat it gives out would melt this frozen shell in one minute. If a bridge of ice whose section was just over two miles square could be formed reaching from the Earth to the Sun, and if all the Sun's radiated heat could be concentrated upon this, it would melt into water in a single second and in seven seconds would disappear as vapour.

The reason we are not burnt up by the Sun's terrific heat is that we are so far away, about 92,900,000 miles. The exact distance cannot be measured within about 100,000 miles. A train, running at 60 miles an hour without any stop, would take 175 years to reach the Sun, and the fare, at 1½d. a mile, would be nearly £600,000. A cyclist travelling at the rate of 100 miles a day without a stop would take about 2,550 years to reach the Sun, so that if he had started in the first year of the Christian Era he would still have travelled only about three-quarters of the distance. The light from the Sun reaches us in 499 seconds.



A photograph of the Sun showing two series of sunspots. Each dark spot is a hurricane of fire big enough to swallow up the Earth several times over The Moon's orbit, which is nearly half a million miles across, has been drawn on the Sun to the same scale. It will be noticed that the Sun's surface is less bright at the edges. This is because we see the edges through a greater depth of the Sun's fiery atmosphere, which, as a consequence, cuts off some of his brilliance. Below are the planets drawn to the same scale as the Sun's photograph. They could all be packed into the Sun many times over

A Giant Indeed

Compared with the Earth the Sun is indeed a giant. Its diameter is 865,000 miles, or nearly 110 times that of the Earth, and if the Earth were placed in the centre of the Sun the Moon would circle round in its orbit far inside the Sun's surface.

As to size, 1,300,000 Earths could be packed inside the Sun, and yet the Sun is only 333,000 times the weight or mass of the Earth. This is because, being so hot, its average density is much less than the Earth's. The Earth is about 5½ times the weight of a ball of water of the same size, but the Sun is less than 1½ times the weight of a sphere of water its size. That is, the Sun's density is less than 1½ times that of water; the Earth's is 5½ times.

But although its matter is less dense than the Earth's, its great size makes the Sun's gravitation very powerful If a man could be suddenly transported to the Sun's surface and live, he would weigh about two tons, and his feet would be so heavy that he would be quite unable to lift them and walk.

A hundred years ago it would have seemed impossible that we could ever actually know what the Sun was made of. But a marvellous instrument called the spectroscope, of which we read in other parts of this book, has revealed to us that the Sun is made of the same materials as our Earth.

Elements found in Sun and Earth

About forty of the elements found on the Earth have been discovered in the Sun, nearly all of which are metals, including silver, iron, zinc, lead, tin, aluminium and calcium The gas helium, which is so useful for filling airships because it is not inflammable like hydrogen, and is yet very light, was discovered in the Sun before it was found on the Earth.

The Sun turns round on its axis in rather more than 25 days, but, curiously enough, all its surface does not travel round at the same rate. The equator rotates in less time than the parts on either side of it. This is because the Sun is not a solid but a gaseous body We know the Sun rotates, because we can see large dark spots on its surface travel right across, disappear, and then later on reappear on the other side

appears mottled or granulated, as though made up of small luminous masses with darker openings between. Because of their appearance, they are often called the "rice grains."

Their nature is something of a puzzle to scientists, but it is generally believed that the photosphere is a sheet of clouds floating in a less luminous

Part of the Sun's disc with the Earth and Moon all drawn to the same scale

atmosphere, just as clouds of water vapour float in the Earth's atmosphere. Professor Young says the photosphere is intensely brilliant for the same reason that the mantle of a gas burner outshines the flame which heats it.

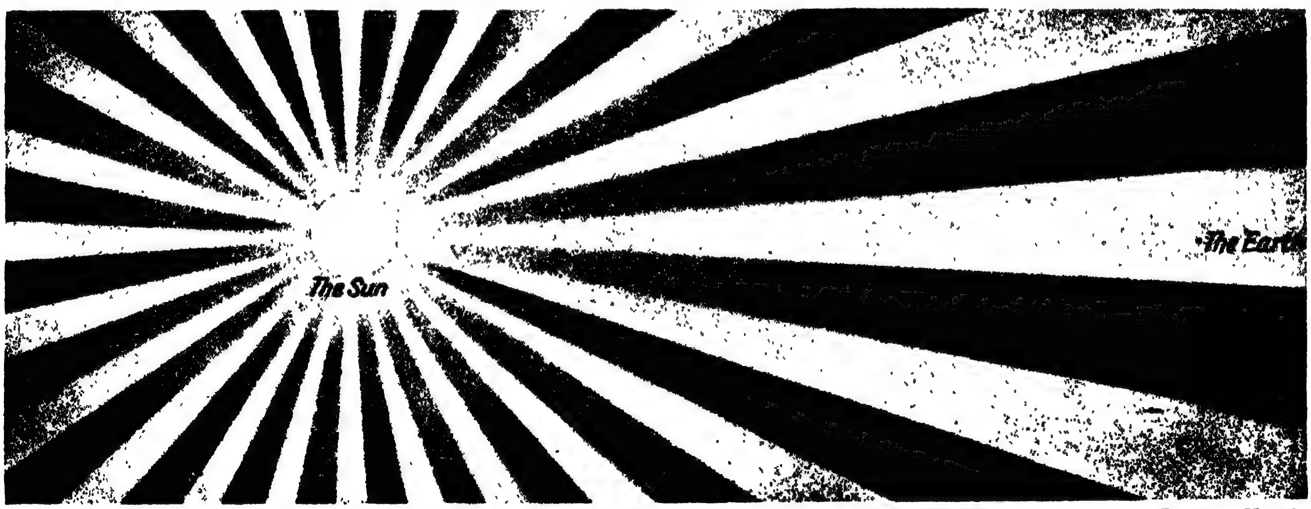
total eclipse. It is not evenly distributed like an atmosphere, but has streamers reaching out at various parts to a distance of several million miles.

The spectroscope tells us that the corona is due partly to the presence of incandescent gases and partly to reflected sunlight. There is believed to be some kind of dust or fog mixed with the gas, which is possibly of meteoric origin. Very little, however, is known about the corona, for it can only be studied during a total eclipse, and such eclipses occur so rarely that the corona has been examined only for a few hours in the whole history of astronomy.

The Power of Sunlight

As to the light received by us from the Sun, it is about 600,000 times that received from the Moon and 7,000 million times that of Sirius, the brightest of the stars. A good deal of the Sun's light is absorbed by our atmosphere, but its light is said by scientists to be 60,000 times as bright as a standard candle placed at a distance of one yard. The brightest light on earth is the electric arc light, but this is only about one-third as bright as the Sun.

If all this radiant energy received by the Earth from the Sun were to be transformed into mechanical energy, it would amount to three horsepower for every square yard exposed perpendicularly to the Sun's rays. But only a very



The Sun pours out vast quantities of heat in all directions, but only about one 2200 millionth of this reaches the Earth. Yet it is sufficient to bring life and health to man, animals and plants, and is directly or indirectly responsible for all the work done in the world When we use coal in our fires and furnaces we are only using solar energy received millions of years ago

We read about the marvel of these spots in another part of this book.

Men of science, in describing the Sun as seen through a telescope, speak of its photosphere, which means "light sphere," its chromosphere, which means "colour sphere," and its corona, or crown.

The photosphere is the visible surface of the Sun, and when photographed by means of the light of certain elements, such as calcium, the surface

The chromosphere is an outer layer of gas like an atmosphere, surrounding the Sun, and is 5,000 miles or more in depth. We can only see the chromosphere during a total eclipse of the Sun, or through a delicate spectroscope. This chromosphere is made up chiefly of the gases hydrogen, helium and calcium.

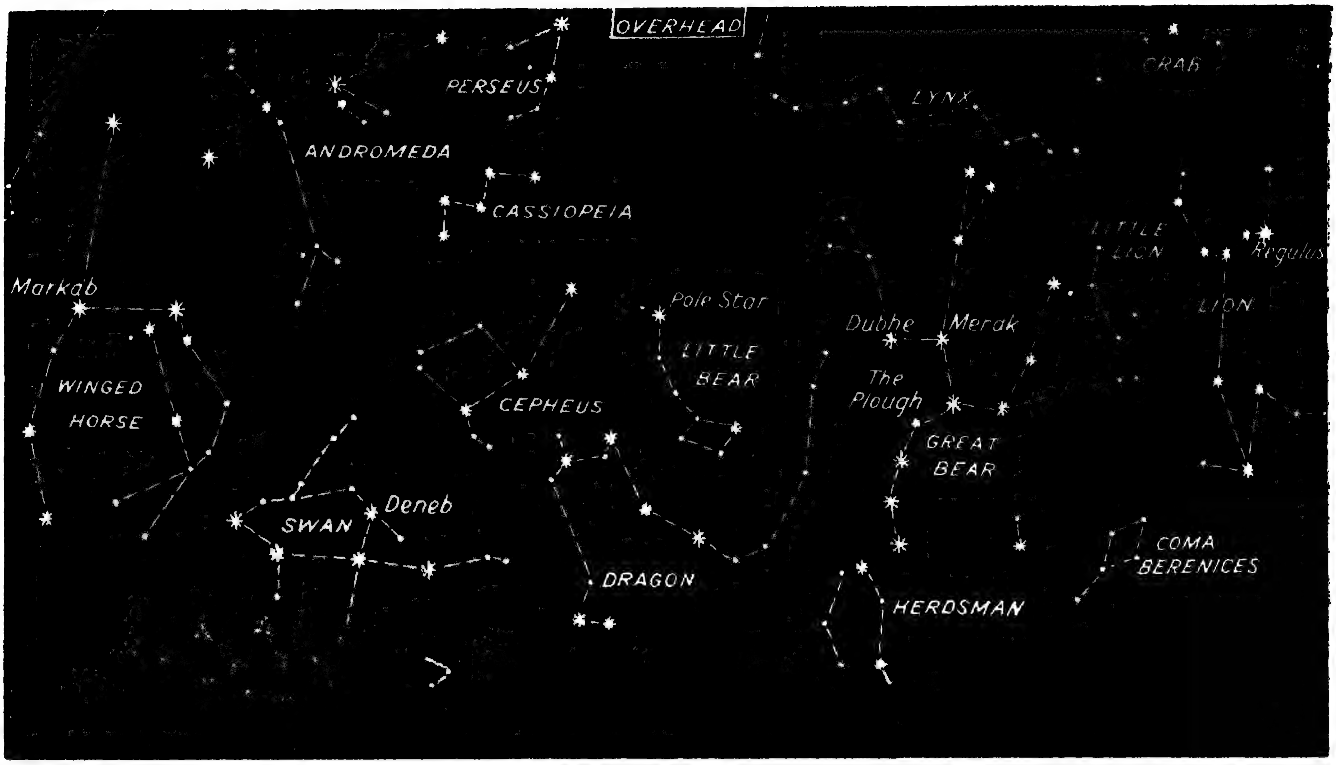
The corona is a beautiful halo of pearly-white colour which surrounds the Sun and is visible only during a

small part of it can be used directly for doing work. Indirectly, of course, all the work we and the animals and the plants do is due to the Sun. The coal we use to drive our ships and trains and work the machinery in our factories is only the stored-up energy of the Sun being used millions of years after it was received by the Earth. The amount of energy received from the Sun varies a good deal with weather conditions, as our atmosphere absorbs much of it.

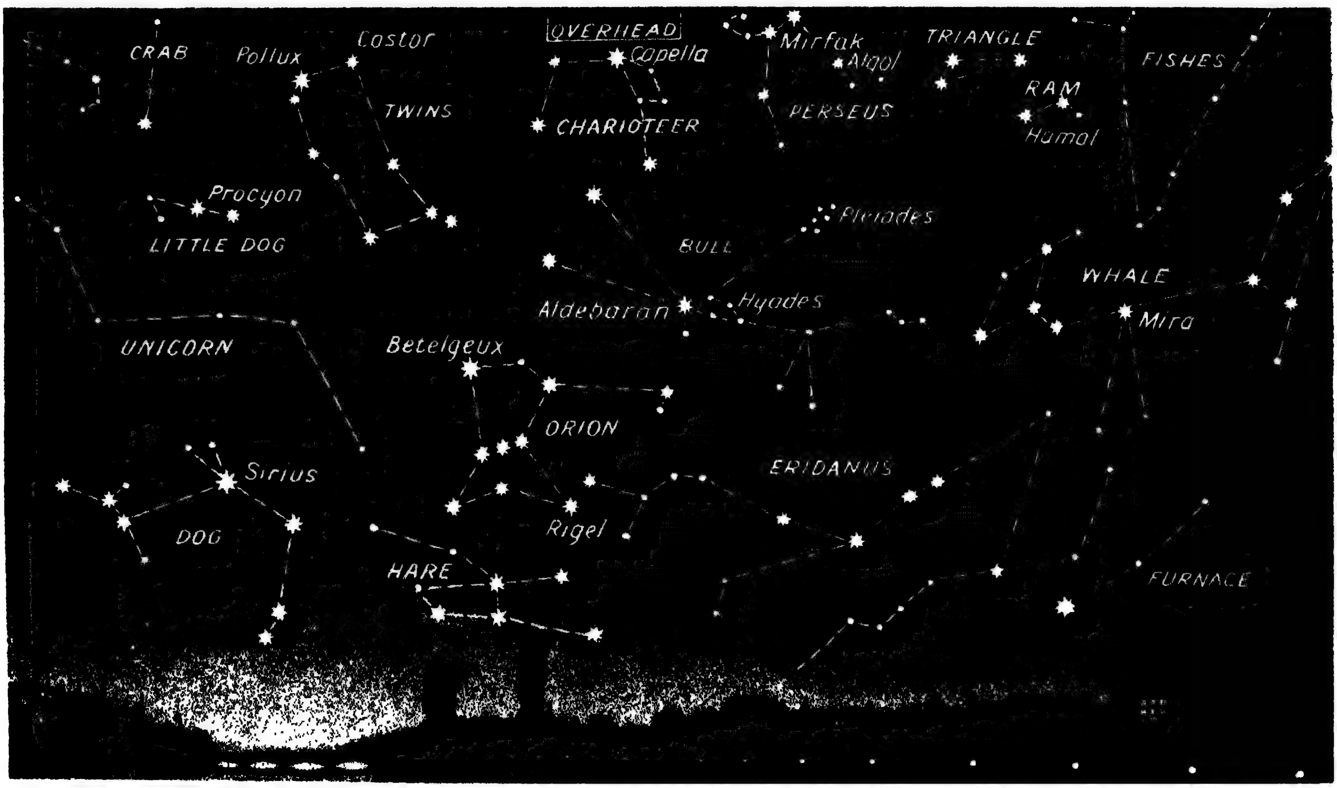
A RAY OF SUNSHINE AND ITS GOOD WORK

All living things are dependent upon the Sun, and this picture shows the work which a ray of sunshine does for plants and man and beast. The sunlight shines upon the soil in which the seeds are planted, and its radiant energy sets up chemical action so that the seeds sprout and the plants grow. The Sun continues to shine, and the chemical action which it causes produces the various substances that form the plant and build it up. Then the cow eats the grass, which has been produced by the ray of sunlight, and in the animal's body it is transformed into milk, which is drawn from the cow by the milkmaid, and supplies human beings with food. The milk helps to build up their bodies. The ray of sunlight is thus still doing its good work, and the food which it produces gives strength to the muscles so that a man can work and gather in the corn and grass which will form food for man and beast

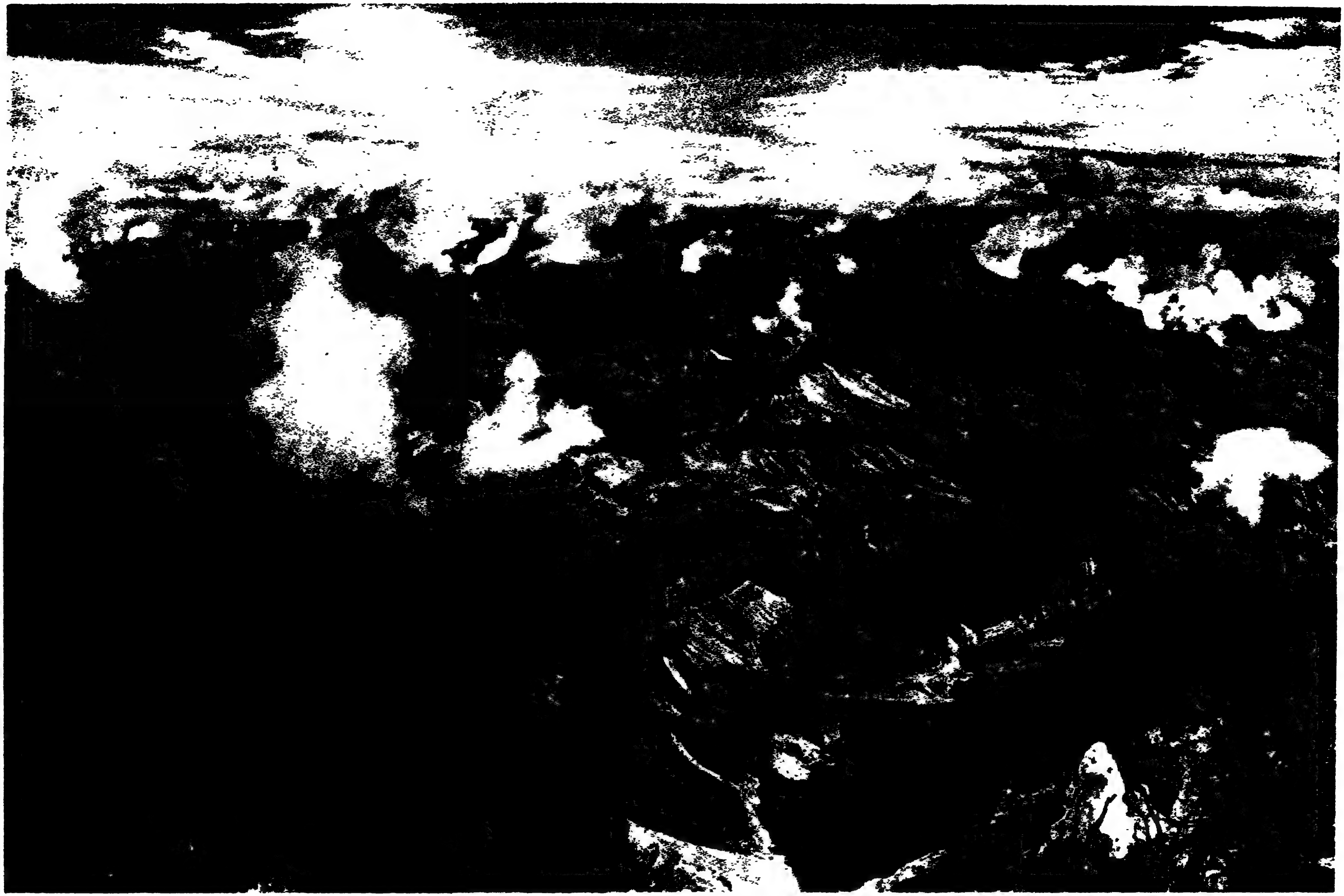
HOW YOU MAY RECOGNISE THE GROUPS OF STARS



Everyone should be able to recognise the chief constellations or groups of stars in the sky. For thousands of years men have looked up at the stars and seen them twinkling, and even before history came to be written, shepherds and others linked together certain stars and fancied they represented animals such as the bear, the goat, the lion, and the crab. It is difficult to see any resemblance to these creatures in the groups of stars to-day, but we still refer to the constellations by their old names, and each of us should be able to recognise these as we look up into the sky. Here we see the chief stars, visible to the naked eye looking directly north at midnight in the middle of January. The sky will have the same aspect as this in the middle of February at 10 o'clock and in the middle of March at 8 o'clock



Here we are looking directly south at midnight in the middle of January. Perhaps the easiest constellation to recognise is Orion, with the belt of three stars in a line. Having located this, we shall be able to recognise the other groups. In both these pictures the names of the constellations are given in capital letters, and the names of special stars in small letters. The Pleiades are a cluster of stars in the constellation of the Bull. This picture serves also for the middle of February at 10 o'clock and the middle of March at 8 o'clock



FANTASTIC WONDERLAND OF TOWERING CLIFFS CUT BY THE COLORADO'S TORRENT

Centuries of ceaseless erosion by the rushing Colorado River have cut in Arizona's desert plateau the mile-deep gash known as the Grand Canyon. Here the river has worked its way down through 800 feet of quartzite, 500 feet of green sandstone, 700 feet of sandstone and limestone, 1,600 feet of bluish marble, 800 feet of grey and bright red sandstone, and 1,000 feet of white limestone, shaping the rock into gigantic terraces, crags, and cliffs and exposing multi-coloured strata that glow cream, brown, green, red, purple, and black in the sunshine. From the rim a visitor can see clouds and lightning flashes over mountain tops far below him

To face page 131

A MINSTREL FINDS A CAPTIVE KING

There is no more romantic story in all history than that of King Richard the Lion-hearted and his friend Blondel the minstrel. It was Blondel who found the King's secret prison away in a distant land and then hastened to England to tell the news, so that Richard might be ransomed. It is a thrilling tale of the stirring days of long ago, and is retold in these pages.

There is no doubt that Richard the Lion-Hearted was a very brave man, and the greatest warrior of his time. The old story that he obtained the name of "Lion's Heart" because, while on a Crusade, he had torn the heart out of a living lion is only a legend, but all his life Richard, although generally suffering from ill-health, was absolutely fearless and never hesitated to rush into the fight against overwhelming odds.

He was a soldier from his childhood. "Fighting was the breath of his life," an old chronicler tells us. "He was furious to rush to arms." When there were no wars—and such times were rare in Richard's days—he would go hunting the bear. When he was on his way to the Holy Land to win back Jerusalem from the Moslem, he called at Sicily and, having quarrelled with Tancred, the King of that island, seized a castle and calling to his men for those "whose hearts were not in their shoes" attacked the town and took it, "quicker than a priest would chant Matins."

It is interesting to know that during his voyage to Palestine, Richard sank a Saracen vessel loaded with munitions by using what the old chronicler describes as "bottles of Greek fire and other dangerous machines of destruction."

A Fierce Swordsman

When he went to the rescue of Jaffa which was being attacked by Saladin, the Saracen leader, he leaped into the sea from his ship with his crossbow in his hand and only part of his armour on, and with a few daring followers routed the besiegers and seized their tents. The Saracen made a counter-attack at night but Richard beat it off with only ten mounted knights, some of whom were unarmed.

So fiercely did he slash with his sword when he went into battle that for years after he left Palestine Saracen mothers used to frighten their crying children by saying "Richard is coming," just as more than six centuries later English mothers scared their bad children by telling them that "Bony" was coming, meaning Napoleon Bonaparte.

An interesting incident happened at the time of the battle of Jaffa. Saladin asked where the King of England was. Some of his officers answered, "Sire, see him yonder on the ground on foot with his men."

"How," said Saladin, "is the King on foot among his men; is he not ashamed?"

Then Saladin sent Richard a horse and charged the messenger to say that such a one as he should not be on foot among his men in such danger. The Saracen messenger performed the commands of his lord. He came to King Richard and presented the horse sent by Saladin. Richard thanked him for it and ordered one of his own officers to mount it, and show its paces before him. After the officer had spurred the horse into a gallop and wished to return towards Richard, he found he could not do so for the horse, in spite of all his efforts, carried the Christian warrior away to the Saracen host. Saladin, we are told, "was much ashamed of this." It was truly an unfortunate end to a generous action.

Richard held up his shield to shut out the view of the Holy City, feeling he was not worthy to look upon it

There are wonderful stories told of how Richard slashing with his sword cut off the heads of many Saracens, and once with one blow cut an Emir in two. Even when he was so ill that most commanders would have retired and gone to bed he had himself carried into battle on a silver litter, propped up on silken cushions, and not only directed the attacks of his crossbowmen, but used a crossbow himself with deadly effect.

But Richard was something more than a brave warrior, and a great commander. He was a poet. He loved to associate with the troubadours of the day, and songs have come down to us said to have been composed by Richard himself. He could not write, but he knew Latin quite well. He never learnt to speak English, his usual language being a French dialect It is a strange thing that he was so popular among the English, for he had very little interest in England, rarely visited it, and indeed only looked upon the country and the people as useful for providing funds for his various enterprises.

Throughout his life of 42 years, Richard spent less than a twelve-month in his English dominions. He loved glory and finery, and when he was married to Berengaria of Navarre, after whom, by the way, the famous Atlantic liner is named, we are told that he wore a rose-coloured satin tunic with a cloak of striped silver tissue, a scarlet bonnet brocaded with gold, and that the hilt of his sword, and his baldrick or belt, were covered with jewels. When he led his fleet of 200 ships to the East, he had his own galley, The Trenchmer, painted red with a great lantern hung at the poop as a signal at night for the other ships.

A Two-Sided Character

Richard, however, had another side to his character, which we must not forget. He could be very cruel. When the city of Acre in Palestine was surrendered to him by the Saracens, he held a number of the enemy warriors as hostages for the payment of a large ransom, and when after a month, during which he repaired the walls and put the city in a fit condition to stand a siege, the

ransom was not forthcoming, he beheaded 2,700 of the prisoners in sight of the enemy.

At Cyprus, which was ruled by a prince who called himself the Emperor Isaac, those of Richard's men who landed first were plundered and badly treated by the people of the island. Richard was furious, especially as the people had declared that the English had tails, so he landed his army, defeated the Greeks, and captured the Emperor. He had sworn that he would not put Isaac in irons, but the unfortunate Emperor was not much better off when Richard loaded him with silver chains.

Of course, the Italian historian who describes Richard as "a bad son, a bad brother, a bad husband, and a bad king" is exaggerating There is some truth in what he says, but we must remember that the lion-hearted king lived in a half savage age, and we must never judge the people of those days by our standards of to-day On some occasions, as in his treatment of his brother John, who had proved disloyal and unfaithful, he could be generous, and he was often good in lending ships and money to his allies the French

London for Sale

He was enthusiastically religious in the queer way that religion was practised in the Middle Ages. He burned to become the champion of the Faith who should deliver the Holy Land from the infidel, as the Saracen was called, and in order to finance the necessary army and fleet he stopped at nothing to raise the funds required

Offices both spiritual and secular were sold to the highest bidder His half-brother, Geoffrey, for instance, paid him £3,000 for the Archbishopric of York, and it is said that Richard declared he would sell London itself if he could find a purchaser.

So pious was he as a Crusader that when he found he would not be able to capture Jerusalem he rode as far as Emmaus, and standing on a spot from whence the towers of Jerusalem could be seen, he held his shield before his eyes so as to shut out the view of the Holy City because, he said, he was unwilling to look on so sacred a city which he could not rescue. Then he went off and captured a caravan of rich merchandise coming from Egypt

Richard performed many exploits of valour in the East, but the jealousies and failures of his allies prevented him bringing the campaign to a brilliant end, and with bad health and news from England that John was plotting against him, he decided to return home.

But he had made many enemies, and the journey from Palestine to England he knew would be perilous. One of his foes was Duke Leopold of Austria, and another was the Holy Roman Emperor, Henry the Sixth, who was very angry at Richard's behaviour in Sicily The Duke of Austria's banner he had thrown down at the taking of Acre on his way to the Holy Land, but, worse still, at Ascalon he had kicked the duke.

Richard had helped his men work on the repairing of the walls of that city, and he wanted the duke to assist also, but Leopold replied that he was not a carpenter or a mason and this made Richard so angry that he gave the duke a good hard kick No wonder, therefore, that Leopold, still smarting from the insult, was thirsting for revenge

Blondel began to play the air of the song

Embarking on a ship for the return journey, Richard was very unlucky, for the vessel encountered terrible storms, and it took him a month to reach Corfu Then, knowing that he had enemies in Sicily and France, he changed his vessel and sailed up the Adriatic in disguise, intending to make the rest of the journey across Europe by land. But the ship was wrecked

Richard, however, managed to reach land, and with a few servants started off He had let his hair and beard grow very long and was wearing the clothes of a peasant of the country, but he does not seem to have acted very wisely, for he spent so much money that rumours spread as to who he really was

Eventually, with only a single page, William Marsh, he reached Vienna He was in great danger, for Duke Leopold, having heard that Richard was in his country, had spies looking out for him. At last, believing that he was discovered, Richard put on the dress of a scullion, and set to work in the kitchen of an inn, turning the capons that were roasting before the fire A spy, however, recognised him, and went and told the duke, and thereupon Leopold sent many knights and soldiers to seize the King He was captured and carried away to a fortress

Another account says that it was William Marsh who was suspected, and that he was seized and carried before the Duke of Austria who made him tell him where his master was, and that Richard was taken prisoner while he slept

Poor Richard was now placed in the Castle of Durrenstein on the Danube, and a chronicler says, "Though his feet were not fettered, yet the filthy guards, their smell, dirt and conversation, were worse than a den of beasts"

Requiting a Kindness

The old records tell us that Richard's friends at home did not know where he was It happened, however, that the King had been kind to a minstrel, a native of Artois, whose name was Blondel This man, as soon as he heard that the King was missing, declared that he would seek him over the whole earth till he found him He thereupon set out and wandered about day after day by land and water, until he had been hunting for a year and a half without hearing anything at all of the missing king

At last he entered Austria, and chance led him straight to the castle where the king was confined Near the building Blondel saw a widow woman who kept an inn, and asked to whom the castle—so fine and strong and well placed—belonged. The woman replied that it belonged to the Duke of Austria.

"Pretty hostess," said Blondel, "is there any prisoner confined in it?"

"Certainly," said the woman, "there is one who has been confined nearly four years, but we do not know who he is. They guard him very carefully, but we have no doubt that he is a gentleman and somebody of high quality."

When Blondel heard this he was delighted, and we are told that his heart whispered to him that at length he had found him whom he sought. He was careful, however, not to give any cause for suspicion to the hostess. That night Blondel slept soundly, for now his mind, which had been so long troubled, was at rest, and the next morning, when the cock's crow announced

the coming of day, he arose and went to a church near by and prayed for assistance.

He then went to the castle and approached the keeper, telling him that he was a minstrel and played upon the lute, and that he would like to remain there for some time and play to him, if the keeper were agreeable. The keeper, who was a young and handsome knight, said he would be glad to engage Blondel as one of his retainers. The minstrel was delighted and went back to the inn to fetch his lute and his wallet

During the next week or so he did all he possibly could to please the castle keeper, and became a great favourite in his household. He remained there all the winter, but was unable to discover who the notable prisoner was.

At last, near the festival of Easter, as he was one day walking in the garden which surrounded the castle, looking in all directions in the hope of seeing the prisoner, a strange thing happened. The King, who was confined in a tower, looking out of the small barred window, suddenly saw and recognised Blondel. Of course he wished to make himself known to the minstrel.

The King Sings

It was too risky to call out, but remembering a song which they had made together, and which, in those parts, no one but the King and Blondel knew, Richard began to sing the first verse of it in a loud and clear voice. Blondel's heart gave a leap. He knew that it was his friend, and he went straight from the garden to the chamber in which he had left his lute. Then he went back to the spot and began to play the air of the song. Each recognised the other, and it was now known where Richard was confined.

Blondel remained at the castle till Whitsun, and was so careful in his behaviour that no one suspected that he had discovered the great secret. Then, going to the keeper of the castle, the minstrel said :

" Sir, if it is agreeable to you I should like to return to my own country, for it is a long time since I left it, and I long to see my friends."

" Blondel, my good brother," said the keeper, " if you take my advice you will not go away, but remain here and I will advance your fortunes."

" Oh, sir," said Blondel, " I cannot remain on any account." And when the keeper found he was unable to detain the minstrel he bade him farewell and presented him with a good horse so that he might travel quickly and comfortably.

Blondel, the story says, travelled so rapidly that before very long he reached England and informed the King's friends there where he was confined and how he had found him. Richard's friends were greatly delighted at this news, for they loved the King as a brave knight, and they determined among themselves that they would send to Austria to the duke and seek to obtain the deliverance of the King. Exactly how much of this story is true it is difficult to say now, but it is a very old one, and dates back to Richard's time.

The Emperor Henry, as soon as he had learned of the King's capture, had sent word to Philip of France, and he had forwarded the news to John in England. Richard and Philip, King of France, who had accompanied the English monarch to the Holy Land, were supposed to be very close friends, and as a proof of this the historian tells us that they ate from the same plate and slept in the same bed. Another historian, however, modifies this story of very close friendship by telling us that they merely ate at the same table and slept in the same room. But Philip had always been jealous of the King of England, and now he and the Emperor and John conspired to keep the secret of Richard's capture for some time. But when the news was known to Richard's friends they at once sent off two messengers to Germany. Some say these were knights, and others that they were abbots.

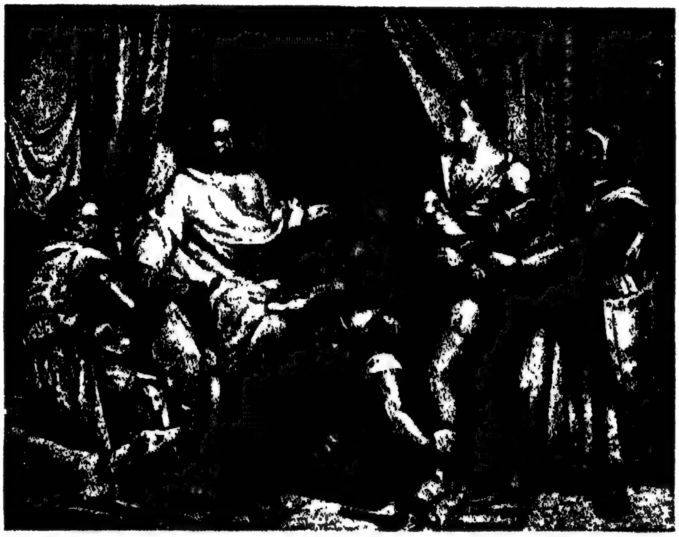
Meanwhile, the Emperor bought the prisoner from Leopold of Austria, but Richard's mother wrote to the Pope, who threatened Henry with excommunication. It was regarded as a great outrage that the Holy Roman Emperor should hold as a prisoner the brave warrior who had done so much to win the Holy Land from the infidel.

The messengers from England found Richard, who was now confined near Speyer, and after some negotiations the Emperor fixed his ransom at £100,000. The messengers returned, and with a good deal of difficulty this huge sum, for those days, was raised in various parts of Richard's dominions, some in England, some in Normandy, some in Anjou, and some in Aquitaine. It is recorded that Caen gave more than London, and that Richard's brother John, who would have liked to have seen the English King remain a prisoner in Germany, stole the money collected on his own lands for Richard's ransom.

It was another year, however, before the King was set free, but at last, on March 20th, 1194, after he had been absent from his kingdom for over four years, he landed in England, and, going to London, was received at St. Paul's Cathedral with great joy and with solemn processions.

Richard lived for another five years, but he became more cruel as he got older, and he was very annoyed when he was given the nickname of " the fat man from Poictiers," he having put on a good deal of flesh.

His last act, however, is to his credit. He was besieging the castle of Chaluz, when he was struck by a poisoned arrow shot from the walls. Fever set in, and very soon it became clear that the King would die. When the castle was taken the archer who had shot the fatal arrow, a young man named De Gurdon, was brought before Richard.



Richard generously ordered the brave youth to be released

A Generous Deed

" What was your grievance ? " asked the dying King.

" You have killed my father and brother," replied the archer, " and I hope that I have killed you."

Richard showed no resentment, but generously ordered the youth to be released. His followers, however, took the young man away and killed him.

It was a rough age in which Richard lived, and there were few, if any, men of power who were not cruel at times. As we have already said, we must not judge them by our own standards, and among those who lived at the same period Richard certainly holds a high place for bravery and even for generosity.

He was undoubtedly a great leader of men, and all the knights and soldiers who fought under him loved him, while, as we have seen, his enemies respected and feared him. He was quick to realise at a glance the moral qualities of a man, and it was said of him " that no one who was a coward or whose conscience accused him could bear to be with him." He made up his mind quickly when decisions had to be taken, but sometimes his love of money made him hesitate, and an old writer has, on this account, given him the name of Richard Yea-and-Nay.

THE ROUND EARTH ON A FLAT WALL

It is quite impossible to portray accurately on a flat surface an outline from a round globe, and therefore none of the maps in our atlases can possibly be correct. But we cannot carry about with us round globes representing the Earth, nor when we want a small part of the Earth's surface represented in large detail, as for example, an English county, can we conveniently use a globe large enough for our purpose. We therefore have to do the best we can and show the Earth or part of its surface as if it were flat, just as these boys have done by drawing the world on the wall of their playground. The making of maps is a great science, and all sorts of devices have been adopted to get as near accuracy as possible. We read about some of these on the opposite page and elsewhere in this book

WONDERS of LAND & WATER

WHY FLAT MAPS ARE NOT ACCURATE

The story of maps and how they have come to be made is a great romance. All kinds of scientific men have to get to work before we can have anything like a reasonably accurate map of a country, or even part of a country. Surveyors and mathematicians and physicists and opticians all get busy before the cartographer, as a map-maker is called, can draw a picture of the country on paper ready for our atlases. Here are some very interesting facts which we should know about maps and map-making

We have many atlases and many maps, some showing the world as a whole, some specific countries, and some smaller areas, and very useful these are. By looking at them we are able to see the relation of one place to another; to notice that a certain town is north-west of another town, and south-east of a third town; that one city stands on the right bank of a river and another on the left bank; that one river runs north and south and is fairly straight, while another runs east and west and curls about like a serpent. We can see, too, from the map, the outline of a coast, the position of the bays and gulfs and capes, and all this helps us to get an idea of what a country is like which would be impossible if we had no map.

We must remember, however, that all maps of the world, and even of countries and large areas must, of necessity, be incorrect. It is quite easy to see why this is. The Earth is in shape something like an orange, that is, a ball flattened slightly at the poles.

An Orange Experiment

Now it is quite impossible to see the whole surface of the orange at one time exactly as it is. We can, of course, look at the orange first on one side and then on the other side, and if we want to represent it on paper we can photograph the two sides and place them side by side as we have done in the picture on this page.

On the other hand, we can take a penknife and, dividing the whole of the orange peel into lozenge-shaped sections, spread this out as also shown on this page. The peel of the orange is soft and elastic, and so when we have removed it from the orange we can spread it out and press it down fairly flat.

Now the Earth is like the orange. If we could go away some thousands of miles into space, taking a camera with us, we could photograph one side of the Earth, and then, when it had turned round on its axis, we could photograph the other side. But while the pictures would give us a very good idea of what the Earth looked like from space, they would be of little use as maps, for we should see the sides of the globe in perspective, and so the shapes of the countries would be lost.

Something That Is Impossible

A representation of the Earth made in this way would give us an idea of the continents and seas only in that part which was immediately in front of the camera. All other features would recede and dwindle in perspective. A map of the world made in this way would be of very little use.

The difficulty in making maps is, of course, that it is absolutely impossible to represent exactly a curved surface on a flat sheet. The best map of the world is, of course, that found on a terrestrial globe. Such a globe can be obtained quite cheaply, and in all sizes, and no one who wants to get an idea of the Earth on which he lives should be without, at any rate, a small globe.

But the difficulty of having a map of the world in the form of a globe is that while it gives a good idea of the world as a whole, even the biggest countries on the largest globes are too small for us to study such details as rivers, lakes, mountains, cities, and so on.

If we want to realise how difficult it is to make a flat map of any considerable part of our globe we can perform a little experiment. Get a cheap indiarubber ball, one of those plain ones without any paint or markings. On it draw any rough outline.

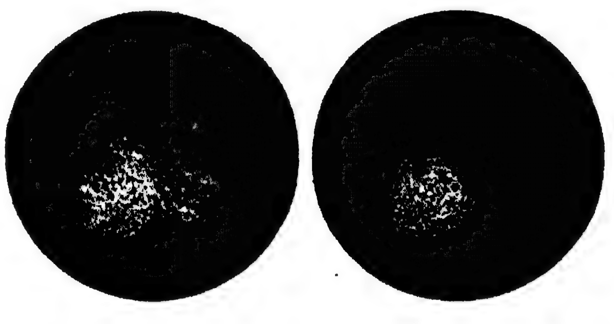
Now cut a good-sized square piece from the ball and lay it on a sheet of paper. It is, of course, humped up in the centre. But rubber, being elastic, can be pressed and stretched, and we can make the piece of the ball lie flat on the sheet of paper by stretching the edges. It is a good plan to pin each angle down with a drawing pin as we stretch it. In this way the round piece of ball is made into a flat surface.

Distorting an Outline

But as we see when we look at the outline which we drew, this has become distorted. If before we press the skin out flat we mark two points on the side of the square, half an inch apart, we shall find that these points are now considerably more than half an inch apart; while another two points near the middle of the square would be almost in the same position as they were when on the ball.

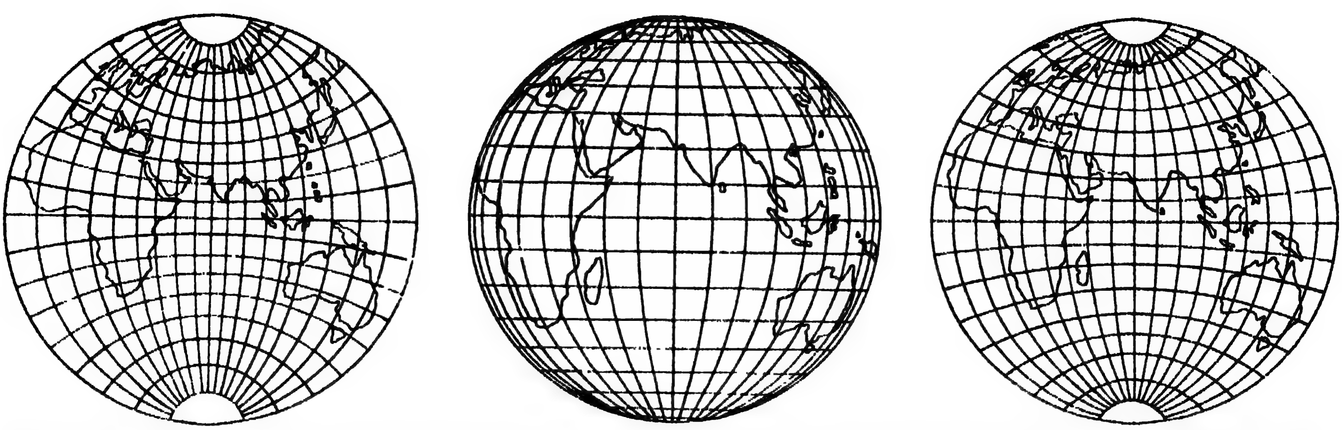
Not only are the points marked on the side of the square farther apart from one another, but they are also farther apart from the centre of the square.

The whole outline which we drew has become distorted, and so, although we have a flat map in place of a curved one, scarcely anything is really in its true position in relation to the other parts.



One way of representing an orange on a flat sheet is to show the two sides in perspective as here

Another way of showing the round surface of an orange on a flat sheet is to cut the peel into many segments and lay them out flat

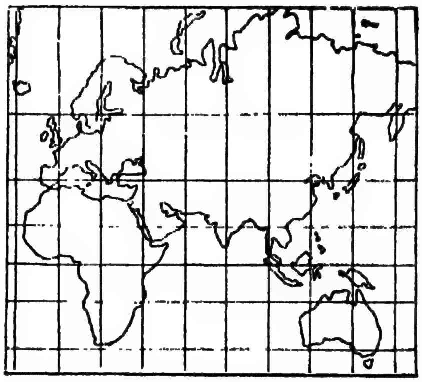


The Eastern Hemisphere in three ways: on the left is the Stereographic Projection, in the centre the Orthographic, and on the right the Globular

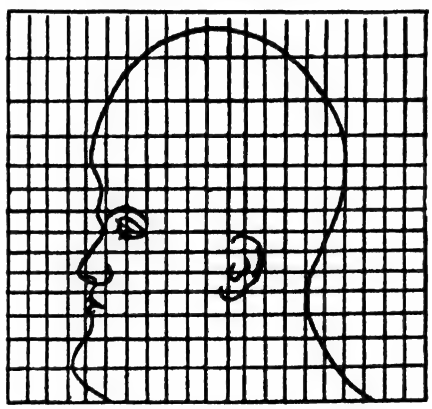
We can see by this little experiment how difficult it is for those men who want to make maps of the Earth's surface to do so. We can spread out the piece of rubber ball flat by stretching its corners and sides, but of course the Earth is rigid, and in any case we cannot stretch out the Earth itself as we can the ball.

What, then, are we to do? We must have maps, and we must have them as accurate as possible. Well, men have thought out all sorts of clever methods of portraying the surface of our round Earth on flat sheets, so that the maps could be hung on the walls or bound together in books.

But in all cases there are distortions of some kind. Some maps are fairly accurate for certain parts, and very inaccurate for others. For instance, in the beginning of our atlases we always find an oblong map of the world which is described as "On Mercator's Projection." It is so called because it is drawn on a plan invented by a sixteenth century Flemish map-maker named Mercator. This map is quite useful in giving us an idea of the shape of various parts of land and sea, and the middle part is fairly accurate as to proportion; that is, India appears in the right proportion to Arabia and North Africa, and Cuba and Haiti are in the right proportions to Mexico.



Eastern Hemisphere on Mercator's Projection



A head drawn on Mercator's Projection

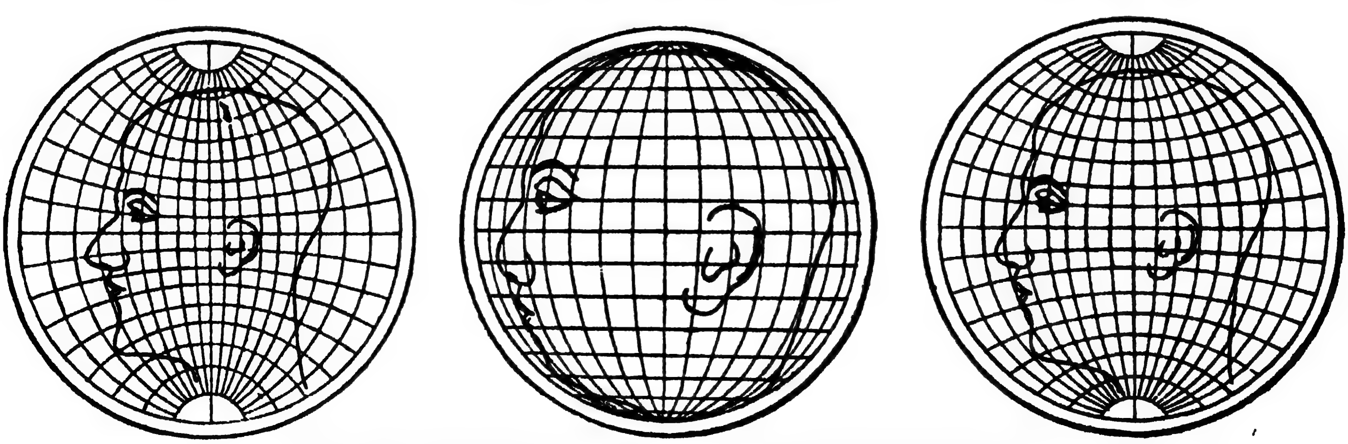
However, when we come to the north and south everything is much distorted and out of all proportion. For instance, Greenland is about 826,000 square miles in extent, while Africa is over eleven and a quarter million square miles; yet on the map of the world, drawn according to Mercator's plan, Greenland appears as big as Africa, and Canada, which is not quite so big as the United States, appears more than twice the size of that country.

When we have a map of the world on Mercator's Projection, with the British Empire coloured red, we get an impression from this distortion of Canada that the British Empire is very much larger than it really is.

On the other hand, when we look at a map that shows the world on some other projection, as, for example, what is known as the Stereographic Projection, Greenland appears less than one-twentieth of the size of Africa, which is equally absurd, if we want to see them in anything like their true proportions.

It is interesting to take an atlas which shows the world on Mercator's Projection and also in hemispheres, and then to compare the various countries with these parts of the world as they appear on a terrestrial globe. We shall realise then the difficulties of map-making.

Of course, for small areas like the counties of England, there is not very



The same head drawn according to the Stereographic Projection (left), the Orthographic (centre), and the Globular (right)

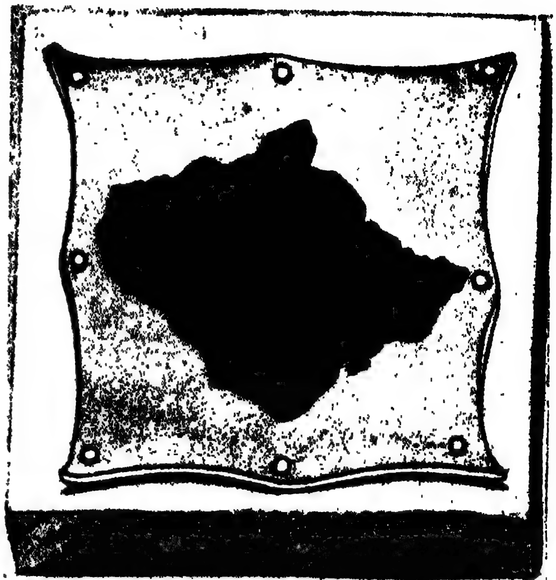
much difficulty Here the area is so small in proportion to the world as a whole that the rotundity of the Earth's surface is very little, and so the county can be depicted with almost true accuracy on a flat sheet.

Photograph of a rubber ball with a drawing of an island

In another part of this book we read of some of the devices that men have invented in order to make flat maps.

The story of the atlas and how it has reached its present form is quite a romance. In the old days the men who drew maps made up for their lack of knowledge and lack of accuracy by making their maps look very interesting and artistic. They always put a great deal of decoration on the maps, with pictures of ships and animals and towns. The names of the countries and other places were printed in letters with plenty of scrolls and flourished. They also gave elaborate borders to their maps, and the colouring was very bright.

But considering the great difficulties under which the early geographers and map-makers laboured it is astonishing that they were able to be as accurate as they were. In some of the maps of the seventeenth century, and even of the century before, the outlines of the continents and countries are remarkably true. This applies to such parts as Africa, India and, of course, Europe, with the Mediterranean Sea



Part of the rubber ball laid flat showing distortion

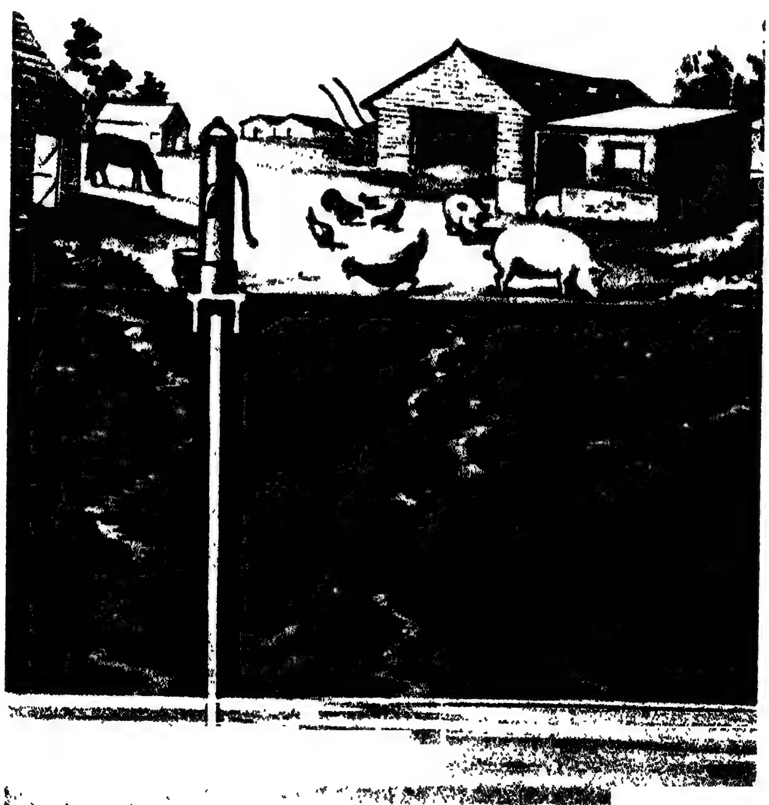
THE IMPORTANCE OF A PURE WATER SUPPLY

None of us can live without water. That is why, when professional fasters abstain, as they can do, from taking food for forty days, more or less, they invariably have to drink water every day. No one can live without water for more than a few days

But quite as important as the water supply itself is the purity of it. There is little doubt that the great epidemics of plague in olden times were largely due to the contaminated water which was drunk by the people. No one understood about disease germs in those days or knew that water could easily become dangerous

The Need for Care

The water supply of large towns can now be relied upon, as it is regularly tested, filtered and, if necessary, chemically purified. But in isolated country districts, where people are dependent upon wells that do not go far down, great care should be taken to see that the water is pure. It may look pure and yet contain disease germs.



In this picture we see why it is often unsafe to drink water from surface wells with or without pumps. Impurities from the surface percolate through the soil to the water. Refuse should never be left near wells and pumps

The picture on this page shows how the water supply from surface wells is contaminated through impurities percolating through the soil to the underground supply. Domestic animals, poultry, manure heaps and all such sources of contamination should never be allowed near any well from which drinking water is drawn.

In the Old Days

Serious and sudden epidemics of disease in a district can usually be traced to pollution of the water supply. But even where there is no epidemic, ill-health may be caused to individuals through impure water.

In the old days there was an excuse, for people did not understand these matters, but now everyone should take care that no decaying matter or animal impurities are allowed to lie near a source of drinking water, such as a surface well.

Filtering alone does not remove disease germs from water.

A GREAT STONE BRIDGE MADE BY WATER

There are in different parts of the world wonderful natural bridges of rock like this one to be seen in Utah, America. It is interesting to know how such bridges are formed. In some past age a river with a waterfall has flowed over rock containing deep open cracks. Some of the water has descended through a crack, and after reaching a lower level worn a passage for itself through the rock to the river below the falls. Gradually the passage has been made bigger, until at last it has become large enough to take all the water of the river. The waterfall has thus been shifted back from its original position. Gradually more and more rock has been worn away, till at last the only part left was a natural bridge near the place where the fall originally went over the rocks. Indeed the fall in ancient times may have actually flowed over the top of this bridge. Another famous natural bridge is to be seen in Virginia

HOW DAY AND NIGHT COME

Every 24 hours there are two varying periods of light and darkness, and these we call day and night. We owe these changes to the fact that the Earth whirls round and round on its axis,

How half the Earth has day and half night

A simple experiment to explain day and night

so that in turn every part of its surface is lighted up by the Sun. If the Earth kept still then the part turned toward the Sun would enjoy perpetual light, while the other side would be plunged in permanent darkness.

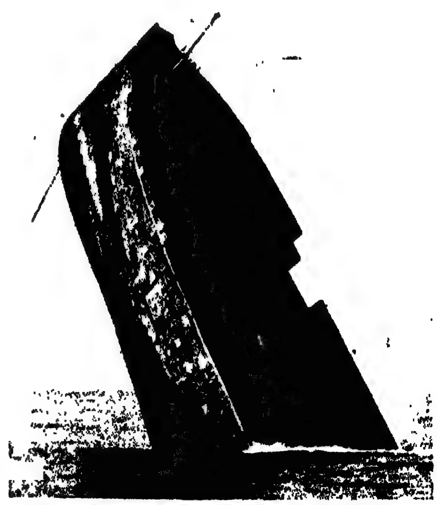
The Earth's axis tilts. If it did not do so day and night would always be equal in length. But since the axis is inclined the length of day and night varies from day to day. We can see this by a very simple experiment.

Stick a knitting needle through an apple from top to bottom, then tilt it at an angle of rather more than 23 degrees and move it round the edge of a round table with a light hanging in the centre. Keep the knitting-needle as you go round always at the same angle and leaning towards the same side of the room. Then you will find that the North Pole of the apple is at one time leaning towards the light, and at another time leaning away from it. These positions represent summer and winter.

If you stick a pin into the apple so that the head represents England, you will see that this is in the light for a longer period of each turn when the knitting-needle is leaning towards the Sun, that is, in summer, than when the needle is leaning away from the Sun, that is, in winter. That is why there is more daylight for us every 24 hours in summer than in winter.

WHY A WRECK SINKS

When a ship sinks it goes to the bottom of the ocean for as it goes lower and lower its material gets more and more compressed, and is always denser and heavier than the water which, of course, is itself also compressed.



A ship going to the bottom of the sea

THE ROMANCE OF THE PELTON WHEEL

Some discoveries and inventions have been the result of strange accidents, and in the whole realm of engineering there is nothing more romantic than the story of how the Pelton Wheel, an unusually efficient device that is of the greatest importance to-day, was invented. The strange story is told in detail on these pages.

Water has been used as a source of power by man for thousands of years. We find that water-wheels were in use among the ancients, and in all sorts of lands, backward as well as advanced, the water-mill for grinding corn and doing other work is a regular institution.

There are various kinds of water-wheels, as we read in another part of this book, but the most efficient of all water-wheels is the modern type known as the Pelton wheel.

In this wheel a series of double buckets is attached to the circumference, and water, issuing from a nozzle at very great pressure, strikes the buckets in the middle, is deflected to both sides and drives the wheel round at great speed. This type of water-wheel has enormous advantages over the old-fashioned kinds, and as much as 87 per cent. of the power expended is harnessed for use.

It is very serviceable where there is a limited supply of water, but provided that the water is falling from a height so as to get the necessary force. The nozzle from which the water is directed upon the buckets is of small diameter, generally ranging from a quarter to half an inch. The wheels vary very much in diameter, sometimes being as small as six inches and sometimes as great as ten feet.

Pelton wheels are often used for driving dynamos, and a wheel three feet in diameter with a fall of water of 520 feet, can develop 200 horse-power. This is very remarkable when one remembers that such a wheel would use only about 240 cubic feet of water per minute. In no other way could such an amount of water produce such great horse-power.

The invention of the Pelton wheel is one of the romances of engineering. We owe it to the foolishness or obstinacy of a cow. One hot summer day in 1860, a gold-miner was washing the gold-bearing gravel in Nevada in order to collect the grains of precious metal. He had rigged up a length of hose in order to provide a supply of water at sufficiently high pressure to do the work, and as the water supply was at a considerable height the stream came from the nozzle of the hose with considerable force.

As the miner was engaged in this task, a cow belonging to him, which was kept for the use of her milk, went up to the workings to slake her thirst. She nearly upset some of the sluices which the miner had arranged, and so to drive off the cow the man turned his hose upon her. By chance the water struck the cow in her cup like nostrils, and the force of the stream threw her head back sharply.

The miner noticed the effect of the water stream on his cow's nose, and

This curious scene was the beginning of one of the greatest inventions in hydraulic engineering that the world has known. The cow really contributed the idea which developed later into the valuable Pelton Wheel, a form of water turbine

suddenly a brilliant idea came to him. He would make a water-wheel with receptacles formed like the cow's nostrils, and he felt sure that this would be much more efficient than any of the ordinary wheels then in use.

A Great Idea

The man lost no time. He rigged up a waggon wheel on an axle so that it would turn freely, tied a number of empty cans to the rim of the wheel and when all was ready directed his hose stream upon the cans. The wheel went round with a whirl, and so long as he kept the stream directed in one position, that is directly at the openings of the cans, the wheel continued to rotate with great speed.

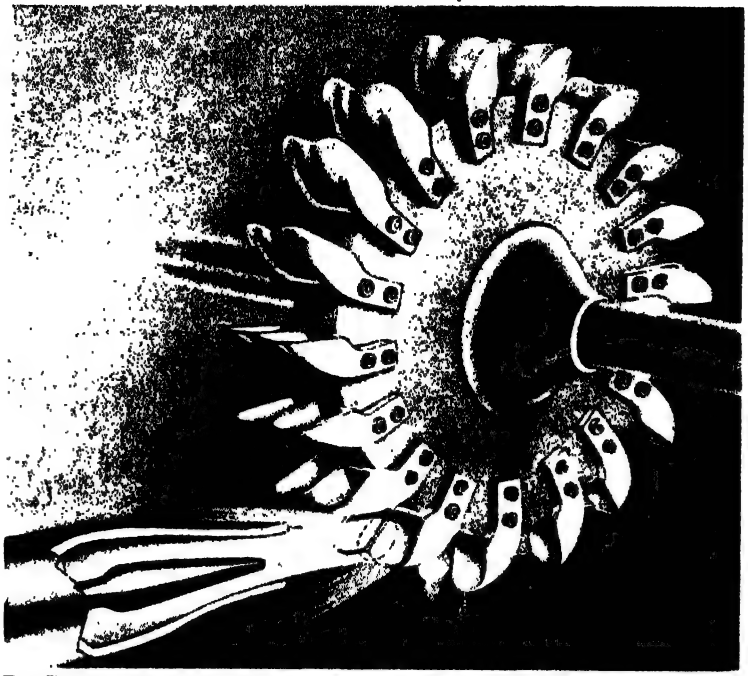
"Here," thought the miner, "is a great idea," and while he still went on with his gold-mining, he spent some time constructing a complete model of the new kind of water-wheel. It more than met his expectations, but here the matter rested for some years. No one seemed interested.

Then in 1885, the miner went to San Francisco and exhibited the wheel. He managed to convince a number of manufacturers of its great commercial possibilities. The Californian gold mines needed some form of cheap power, and here was the very idea. A plant was erected at the mines, a water stream was brought from a great height, and the new device was inaugurated in the presence of a large gathering of miners, who though interested, were somewhat sceptical. But the wheel justified itself at once.

Success Achieved

The demonstration proved a tremendous success, and from that time onwards Pelton wheels, as they were called, after the name of the miner inventor, Lester A. Pelton, were in great demand.

We are not told what happened to Pelton's cow, but certainly the inventor, whose name is now world-famous, must have felt grateful to the animal for giving him such a brilliant and useful idea.



The Pelton Wheel as it is today. A powerful jet of water under pressure strikes a series of double buckets and whirls the wheel round at enormous speed. A needle inside the nozzle regulates the water-jet

In the modern Pelton wheel the inner surface of the buckets is highly polished to avoid friction, and when the stream of water is directed at the sharp edge of the wall between each pair of buckets it communicates as much as 98 per cent. of its energy to the buckets. When the water leaves the nozzle it is not so much a jet, as a solid bar of water. A three-inch jet of water at a pressure of 500 pounds to the square inch cannot be cut through or deflected by the blow of a massive crowbar.

Regulating the Water

The supply of water, and therefore its force, is regulated by means of a tapered needle inside the nozzle which can be moved to and fro so as to make the opening larger or smaller at will. The needle valve is worked by a governor and a motor, and as a reduction of the stream of water would increase pressure in the pipes delivering it, the governor also works an escape valve, automatically opening it when the needle valve closes, and closing it when the needle valve is opened. In this way the power of the wheel can be increased or lessened according to need, and as little water as possible is wasted.

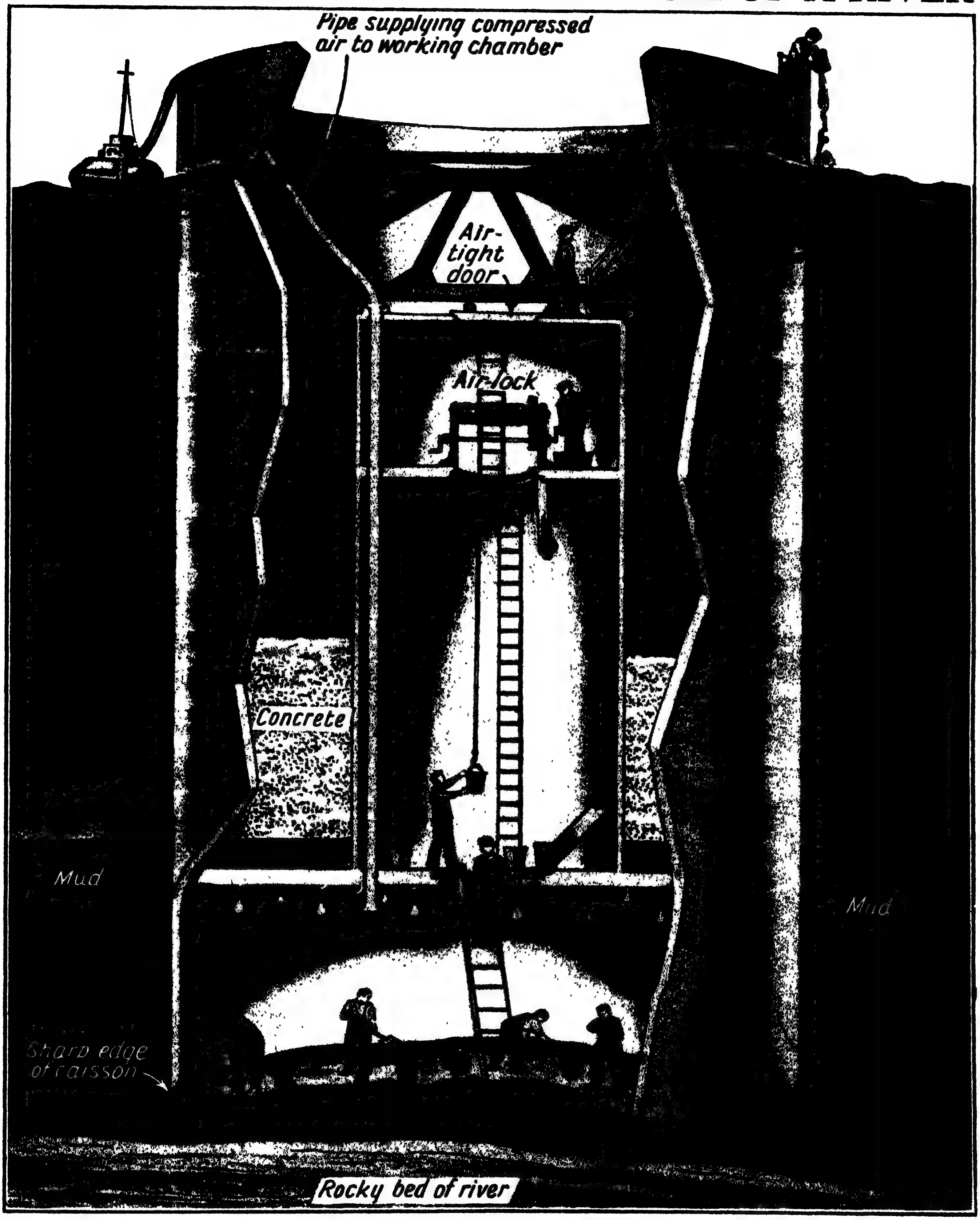
The very first Pelton Wheel made by tying old cans to a waggon wheel

Enormous Pressure

Pelton Wheels are made in all sizes, and they are designed to run at all speeds and to use water of varying pressures. In some the stream of water which leaves the nozzle has the enormous pressure of 935 pounds on every square inch.

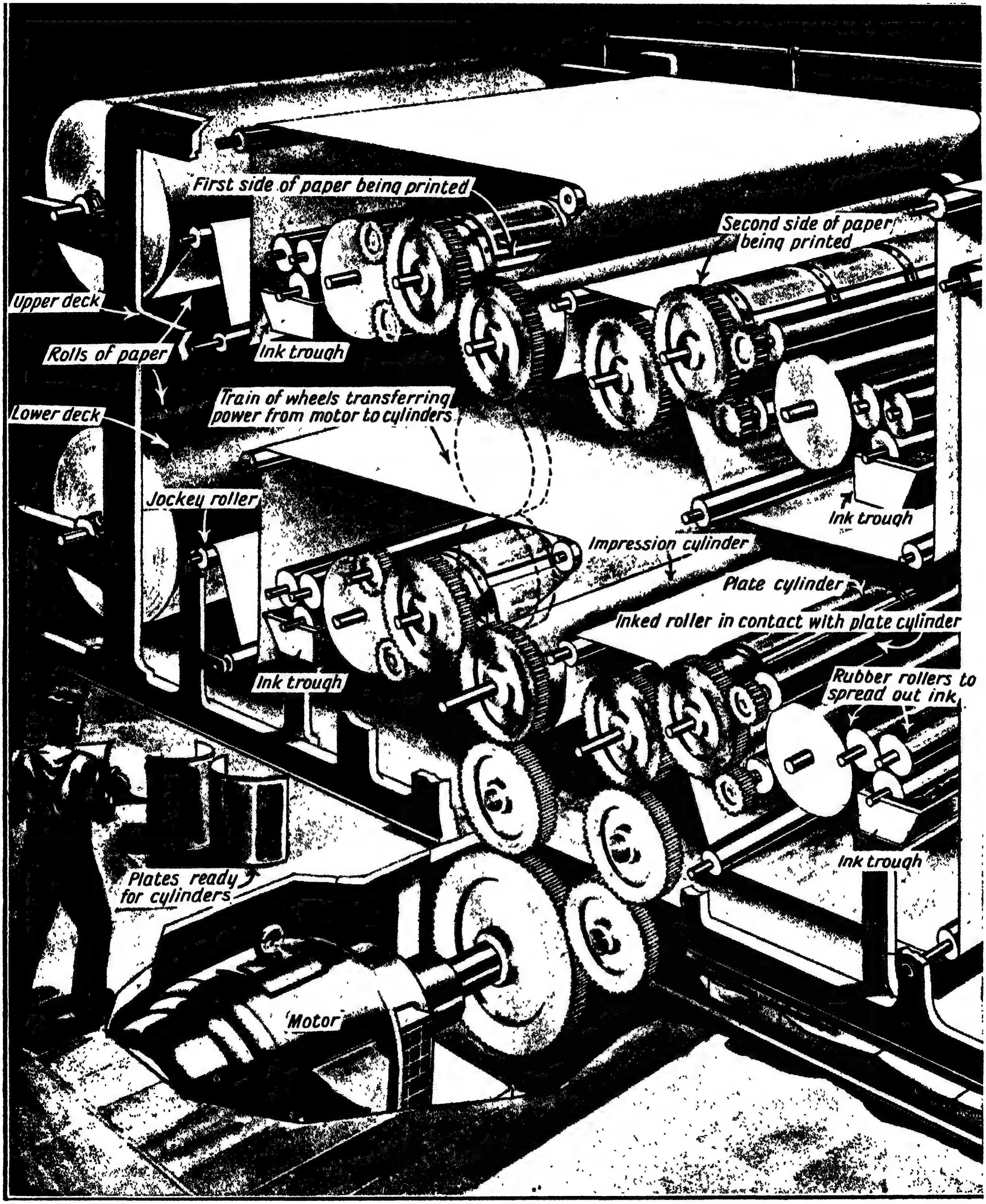
Think of what this means. Mark out on paper a little square with two-and-a-half inch sides. If the stream of a large Pelton Wheel were directed against this the pressure would be over a ton. No wonder the wheels have to be very strongly built of the best steel, and no wonder they whirl round at an enormous speed.

DIGGING A HOLE AT THE BOTTOM OF A RIVER



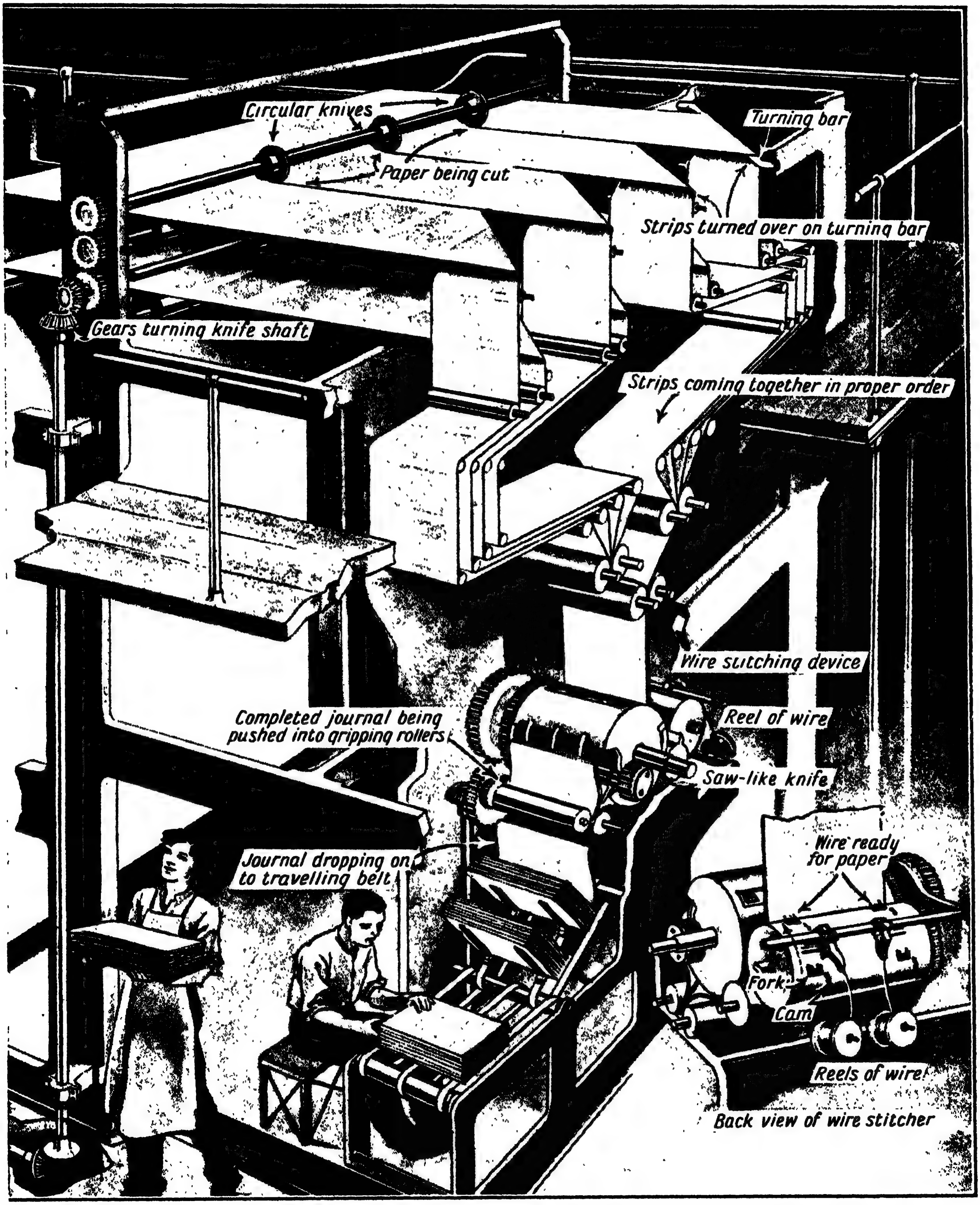
When a bridge is to be built across a wide river, concrete foundations have to be laid. A large circular iron chamber, called a caisson, is sunk in the river bed. Inside the caisson is a floor with concrete to give weight, and underneath is a working chamber into which compressed air is pumped, driving out the water. This is kept filled with compressed air and workmen enter through an air lock to get used to the pressure. They dig out the river bed, and the caisson is then filled with concrete and thus provides a good foundation for the bridge.

THE GREAT MACHINE THAT PRINTS



The machine that prints a newspaper or magazine is a marvel of ingenuity, and in these pages we see how it works. For clearness and simplicity part of the machinery on the far side has been brought to the front. The motor sets moving a whole series of huge rollers or cylinders. Some are to direct the paper, some are covered with ink, and some have bent round them metal plates cast from the type and arranged in pages. The plate cylinder is inked by a roller, and when the paper comes to this cylinder an impression of each page is left behind. There are two tiers to the machine, and both are printing parts of the paper or magazine. As the printed paper leaves the

AND BINDS A PAPER FOR YOUR USE



rollers it passes between a series of circular knives, which cut it into strips the depth of the pages. Then the strips pass over turning-bars and are drawn through rollers, where they are brought together with other strips from the lower tier of the machine. The whole of these pass through an apparatus which binds the pages by stitching them with wire, and cuts them off in separate magazines or journals. The journals then drop on to a travelling belt and are carried away for despatch to the newsagents or booksellers. In the bottom right-hand corner of this page the other side of the wire stitcher is shown, with the reels of wire

WHAT ENGINEERS MEAN BY HORSE-POWER

This photograph of a diesel-electric locomotive built by the British Thomson-Houston Company of Rugby, England, for British Railways, is a good example of how engineers can put a lot of horse-power into a small space. The locomotive develops 827 horse-power and can haul a load of over 500 tons ; imagine the long line of horses that would be needed if there were no engines to do the work

BEFORE the development of machinery men did their work of digging or pulling or lifting as well as they could, merely comparing in a general way the work of a very strong man with that of a man less strong. As soon, however, as machinery was invented and developed it became necessary to find some way of comparing the work one machine was capable of doing with that of another.

James Watt, to whom we owe the steam engine, made experiments with strong dray horses and found that a good average amount of work done by one horse was equal to the lifting of 33,000 pounds to a height of one foot in one minute. Of course, a horse urged on could do more work than this, while over a full day the animal would work at a less rate. However, Watt took this useful average and called it a horse-power. Then he measured the work his engines could do by the amount of horse-power they could achieve. Ever since that time the work of engines has been reckoned in horse-power.

Sometimes we read of an engine having so much Indicated Horse-power. That means the amount of horse-power exerted by the piston. Of course, when we use the power in the engine some of this Indicated Horse-power is lost, and what we actually use in driving machinery is known as Effective or Brake Horse-power. Lifting a weight of 33,000 pounds to a height of one foot requires the same energy as lifting one pound 33,000 feet.

These ten horses struggling to drag a load of about 8 tons provide the standard of work for all engines and machines. But the line of ten horses occupies a greater space than the locomotive above which can haul more than 100 times their load ; and the engineer's 827 horse-power pulls its load for hour after hour, whereas the draught horses soon become tired and must stop to rest

MARVELS of MACHINERY

MAKING 1,500,000 ELECTRIC BULBS A DAY

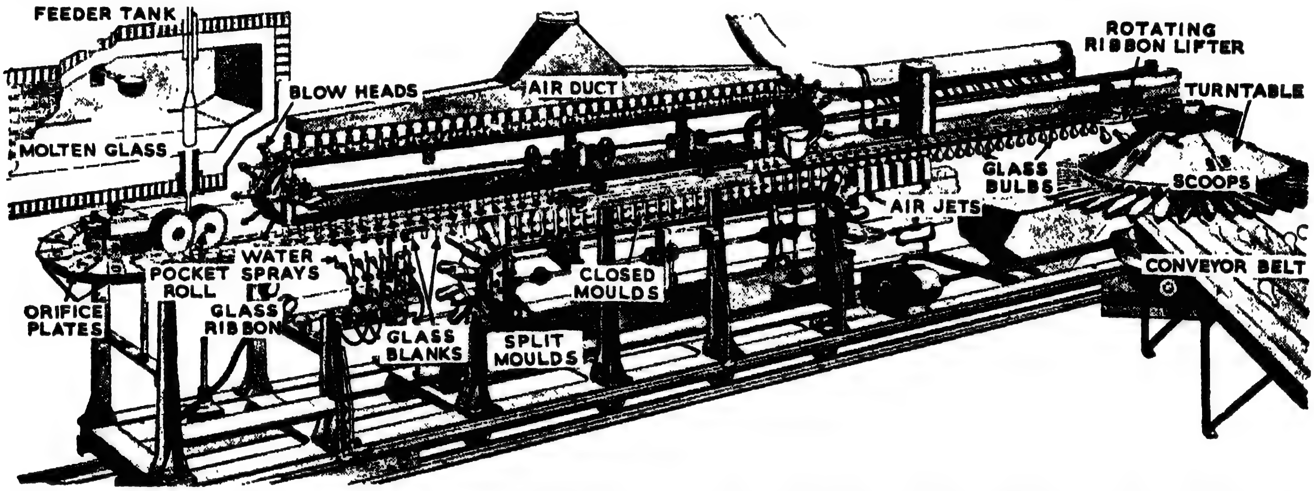
GLASS bulbs of a great many different types and sizes are required in huge quantities for making electric lamps and radio valves. Until about 1920 they were all made by skilled hand blowers, but nowadays automatic machines are used.

One of the largest bulb-making machines, designed by the British Thomson-Houston Co. and the General Electric Co., is at Harworth, near Doncaster, Yorkshire, and can produce three-quarters of a million glass bulbs a day. Two of the machines are in operation at Harworth, and their total daily production, one and a half million bulbs, is sufficient to meet the requirements of all the electric lamp manufacturers in the British Isles and to allow a margin for export to Europe and the Commonwealth.

The factory building is 700 ft. long by 80 ft. wide. At one end is the 100 ft. mixing tower where the raw materials are taken in, and it is from this point that the manufacturing process begins, terminating in the finished products which, packed in cartons, are transferred on a conveyor belt to the railway wagons in which they travel to their destinations in Britain or to the ports for shipment abroad.

Raw materials for making the glass bulbs are delivered directly to the plant by railway wagons and are raised by suction to the top of the mixing tower. The mixing tower, which is built in reinforced concrete, consists of seven silos, extending from the top to the bottom of the tower, each of which can hold 1,500 tons. The raw materials, soda ash, dolomites, limestone, sand and felspar, are fed to their respective silos by a mechanical bucket conveyor inside the building. All the raw materials are obtained locally: sand from King's Lynn in Norfolk, soda ash from Northwich in Cheshire, limestone from Buxton in Derbyshire and dolomite from a source near Doncaster.

Raw materials are mechanically shovelled from their several silos and pass down chutes to the automatic weighing machines two floors below, whence they are discharged in their correct proportions into a rotary mixing drum.



This picture-diagram shows in simplified form the machine that can produce thousands of electric bulbs in an hour. Molten glass from the feed tank falls on to the orifice plates (plates with holes in the centre) and is carried to the blow heads which force compressed air into the glass so pressing it into the moulds which give the bulbs their shape. The bulbs are then cooled by jets of air and fall on to a conveyor belt which carries them away for packing. The whole process of making electric lamps is described on this and the two following pages

On the floor directly below the outlets of the silos are remote-control panels which give an accurate and instantaneous picture of the progress of the materials. Coloured indicator-lights show the conditions in the silos, when they are being replenished, the passage of materials into the weighing machines, their discharge into the mixing drum, and so forth. Most of these operations are remotely controlled by push buttons on the panels, so that a small staff of two men is able to supervise the working of this important section.

From the mixing drum the now thoroughly blended materials are automatically discharged into canisters which are mechanically conveyed on a roller runway to the hopper which feeds the furnace. The hopper discharges into electrically-operated screw-feeders which force the charge, or batch, into the mouth of the furnace.

The furnace in which the raw materials are heated and fused produces 150 tons of molten glass a day. Temperatures are suitably graded through the melting and refining ends, the glass finally passing through the forehearths, which are of the automatic type, and bring the glass to the exact temperature required for feeding to the actual bulb-making machinery.

On leaving the forehearth a controlled stream of glowing, molten glass flows down between two rotating water-cooled rollers at one end of the ribbon machine. One roller has a plain surface, the other contains pockets, or circular depressions, so that the glass issues from between them as a continuous ribbon bearing a series of shallow circular "humps" like the ribbon of "caps" used in a boy's toy pistol. From the rollers, the ribbon is carried on a continuous belt of plates, each of which is pierced with a circular hole that comes accurately into position beneath a "hump."

Moving forward on the plates the ribbon now meets a chain of blowheads which descend on to it from above, each blowhead pressing into the centre of a "hump" directly over the hole in each plate. A puff of compressed air issuing from the blowhead causes the "hump" to be forced downwards through the hole in the plate, the function of which is to fix the diameter of the top of the neck of the finished bulb. The newly-formed bulbs, or glass blanks as they are called, hanging below the rapidly moving ribbon, increase in depth until they meet split moulds which rise from below on a continuous belt and close round them from both sides.

The moulds now begin to rotate, and meanwhile the air pressure from the

blowheads increases so that the glass blanks are moulded to their final shape. During this operation the ribbon, blowheads and moulds are all moving forward together at the same speed. On completion of this process the moulds open, revealing the bulbs, and return on

Fig. 1. Glass rods are fed into the machine and picked up automatically for inserting in the bulbs

their belt under the machine. At the same time the blowheads break contact with the glass ribbon and return along the machine on the upper side of their chain.

The plates, carrying the ribbon with the blown bulbs depending from beneath it, continue to travel forwards while jets of cooling air play upon the completed bulbs. On reaching the rotating ribbon-lifter the bulbs are successively tapped off by the strokes of a hammer and fall into the scoops of a rotary turntable which tip them on to a moving belt for conveyance through a gas-fired annealing oven. The glass ribbon passes down to the floor below where it is water-cooled and subsequently broken up for re-use as cullet or waste glass, while the plates return horizontally behind the machine.

The diagram on page 145 gives a clear picture of the complete process of bulb blowing. Here are some more facts about this amazing machine.

The moulding of the bulbs is a very delicate and precise operation and for this reason the moulds are cork lined. The heat of the glass transforms the cork into fine carbon which readily absorbs water from the cooling sprays that play on the moulds as they pass back under the machine. Coming into contact with the hot glass, the water is vaporised, so that the bulbs are formed in a cushion of steam which leaves them with a polished surface finish.

Each ribbon machine, so called because of the ribbon of glass passing through it, is driven by a 10 h.p. electric motor which is operated under electronic control to maintain constant speed at any setting from a crawl to 1,750 r.p.m.

Of the two machines used, the larger produces from 350 to 500 bulbs a minute in the sizes for 75-watt, 100-watt and 150-watt lighting lamps. Operating on a continuous 24 hour schedule, this machine gives a daily output of approximately 500,000 bulbs. The smaller machine will produce the whole range of valve bulbs up to 44.5-mm. diameter, including all the miniature types, and lamp bulbs from the 25-mm. stop and tail light size up to and including the 65-mm. bulb for the 60-watt lighting lamp. The output of the machine, which runs continuously throughout the 24 hours, is about 1,000,000 bulbs daily.

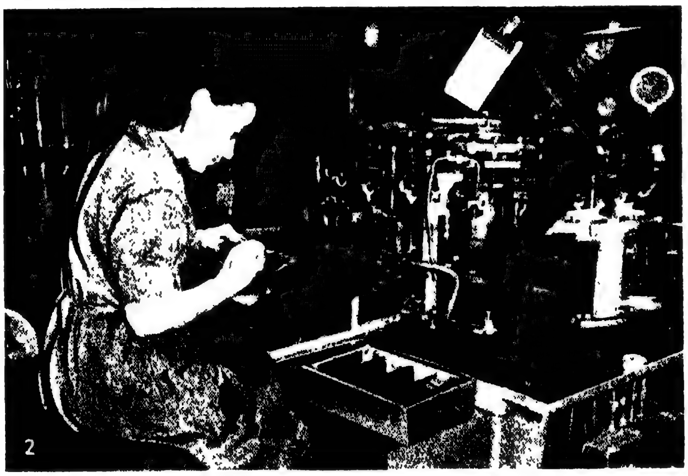


Fig. 2. Lengths of tungsten wire, from which are formed the filaments, are automatically cut to the right size and pass into the machine which places them round the glass rod in the bulb

After annealing, the bulbs are air cooled while proceeding on a conveyor belt to the packers. At the control point five bulbs are picked off the belt every twelve minutes for examination and checking for correct size.

Packing the bulbs into cartons and labelling and sealing the packages takes place on two floors of the main factory building, whence the cartons pass on conveyors to the finished bulb store. This building is 700 ft. long by 110 ft. wide; a railway line enters at one end and extends down one side for the full length of the store. On the opposite side are situated the road loading docks which are conveniently arranged at an angle to allow ample room for backing and turning the lorries.

Inside the store, cartons ready for despatch are stacked on wooden slats and can be easily picked up and transported by means of battery-driven fork trucks. Between twenty and thirty wagon loads of bulbs are despatched from the works by rail every day.

As the manufacture of bulbs is a continuous process, and any interruption would involve wasteful and costly delay, arrangements have been made to ensure continuity of supply, in the event of a power cut, by the installation of emergency diesel-alternator sets. Similarly, oil storage tanks have been provided to enable the furnace to be oil fired should the normal supply of gas fail.

When the glass bulbs leave the ribbon machine they are simply empty bottles, and the next task, after they have been delivered to the finishing factory, is to insert their filaments, extract the air

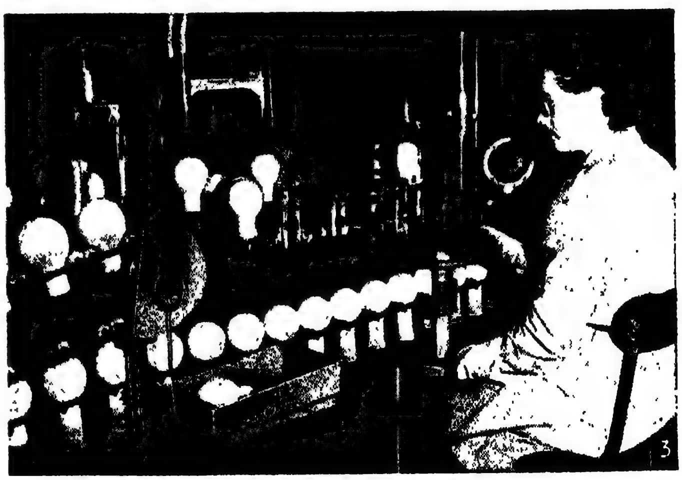


Fig. 3. A shadow of the bulb, now containing rod and filament, is thrown on to a screen so that the girl inspector can check that everything is correctly positioned

from inside them, fill them with gas, and seal the tops with a brass cap. These processes are carried out automatically by machines of the type shown on pages 146–47. The machines were designed and built by Philips Electrical and were photographed while

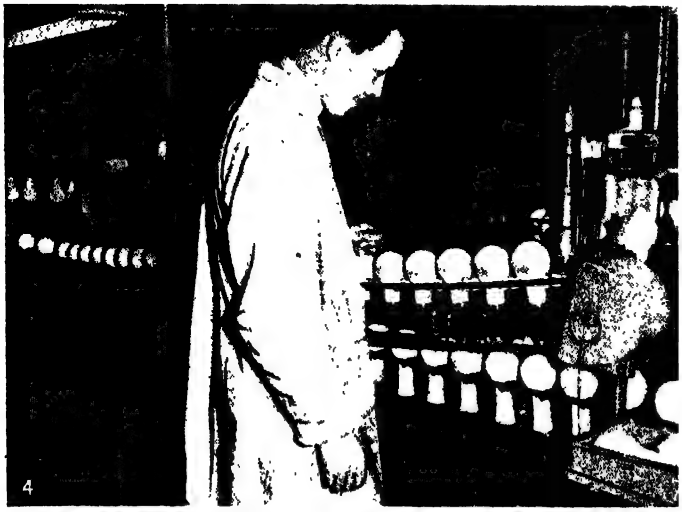


Fig. 4. The lamp has now been filled with gas, and the operator is passing a current through the gas to make sure that the gas content is correct.

working in that company's factory at Hamilton, Scotland.

Just as in making the glass bulbs the raw material was fed in at one end of the factory and the finished article came out at the other, so in assembling electric lamps, bulbs and components are placed in one end of an assembly line of machines and come out of the last machine ready to be connected to an electric supply and light up.

The first section of the machine assembles the internal stem of the lamp, the component parts of which are fed in by an operator. These comprise a short piece of glass rod with two lengths of nickel wire (the lead-in wires), which, leaving the loading point, are correctly positioned by the machine before passing on through a series of flame jets in which the end of the stem is melted and automatically pinched and sealed

In the second stage the filament supports and the tungsten filament itself, fed in by an operator in precise lengths, are mounted on to the stem, the molybdenum supports being automatically so hooked around the filament that it cannot be dislodged.

It is at this stage that a test point is set up. Every filament assembly passes under a special projector which throws its silhouette on to a screen watched by an operator; any flaw in construction so far can be readily detected.

Progressing past this point, the growing lamp then meets its bulb which, held above by a vacuum "grip," is lowered mechanically over the assembly, and passes on to another battery of flame jets in which the base of the bulb is melted, shaped and sealed around the flange. This process is immediately followed, on the next section of the machine, by extraction pumping, and filling with an inert gas. Any flaw in a bulb, however, will operate a mechanism which prevents this operation in the case of the bulb concerned.

The sealing of the exhaust-tube follows, and the lamp is now ready for its brass cap. Special tests are once again made at this point to ascertain that the quantity and quality of the gas are correct.

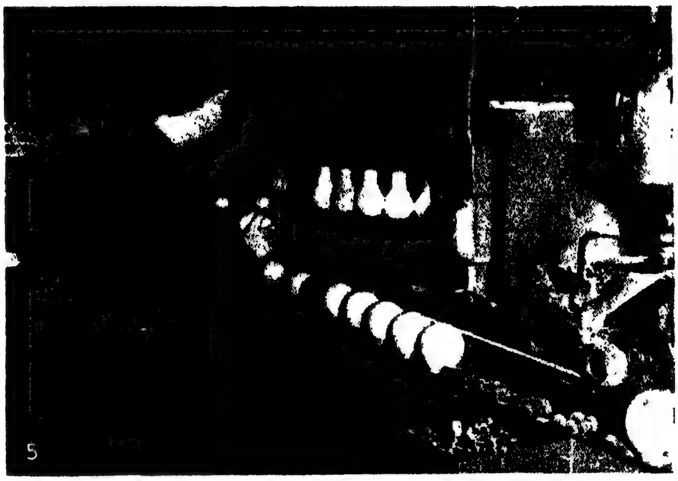


Fig. 5. This machine automatically places the brass cap on top of the lamp and seals it in position with cement.

Next, the lamp passes into the fourth and last stage of its progress; this is the capping mill. A special cement i inserted into the cap which is then dressed on to the end of the bulb, and baked. Finally, the end of the wire supports, still protruding through the base, are automatically cut off, and "fluxed." Two blobs of solder, precisely placed, complete the job of manufacture.

Before it leaves the assembly line the lamp is subjected to tests with a high-frequency coil which indicates, as before, the nature of the gas content (or the state of the vacuum in other types of lamps). It is then thoroughly inspected for the smallest flaw of any description, and so rigorous is this inspection that a lamp is rejected even for a faulty letter in the rating particulars branded on the top of the bulb.

The test department now takes over, and our new lamp, with a batch of others, is subjected to an over-voltage test twenty per cent. above its rating. Surviving that treatment, it is next run on a low-voltage supply and inspected under this condition for even burning. Next, batteries of lamps are switched into series, and again burned to check that they are all of the same voltage rating. Once again, they are subjected to the H.F. coil test and closely inspected. If all is well, most of them are ready for packing.

While the bulbs and components are passing through the machines, inspectors make random selections of finished lamps for special tests. Typical of these are the life tests in which lamps of all types are simply burned continually until their allotted span is exhausted. Other tests are highly technical and cannot be described here, but a simpler one can. This is the test for the cement which secures the cap to the bulb. It must survive a month in salt water!

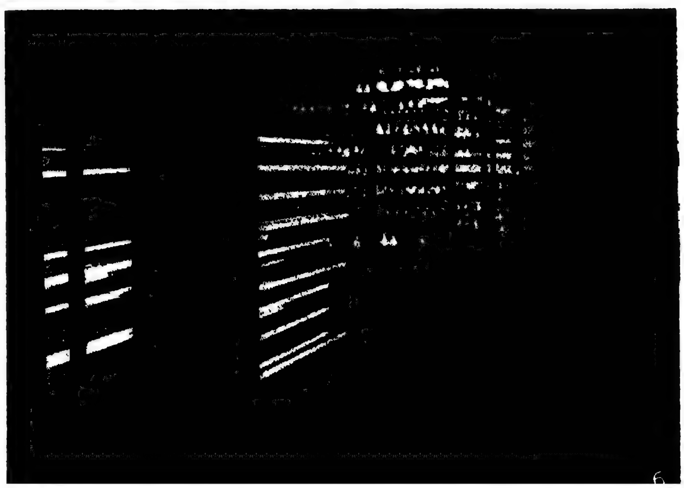
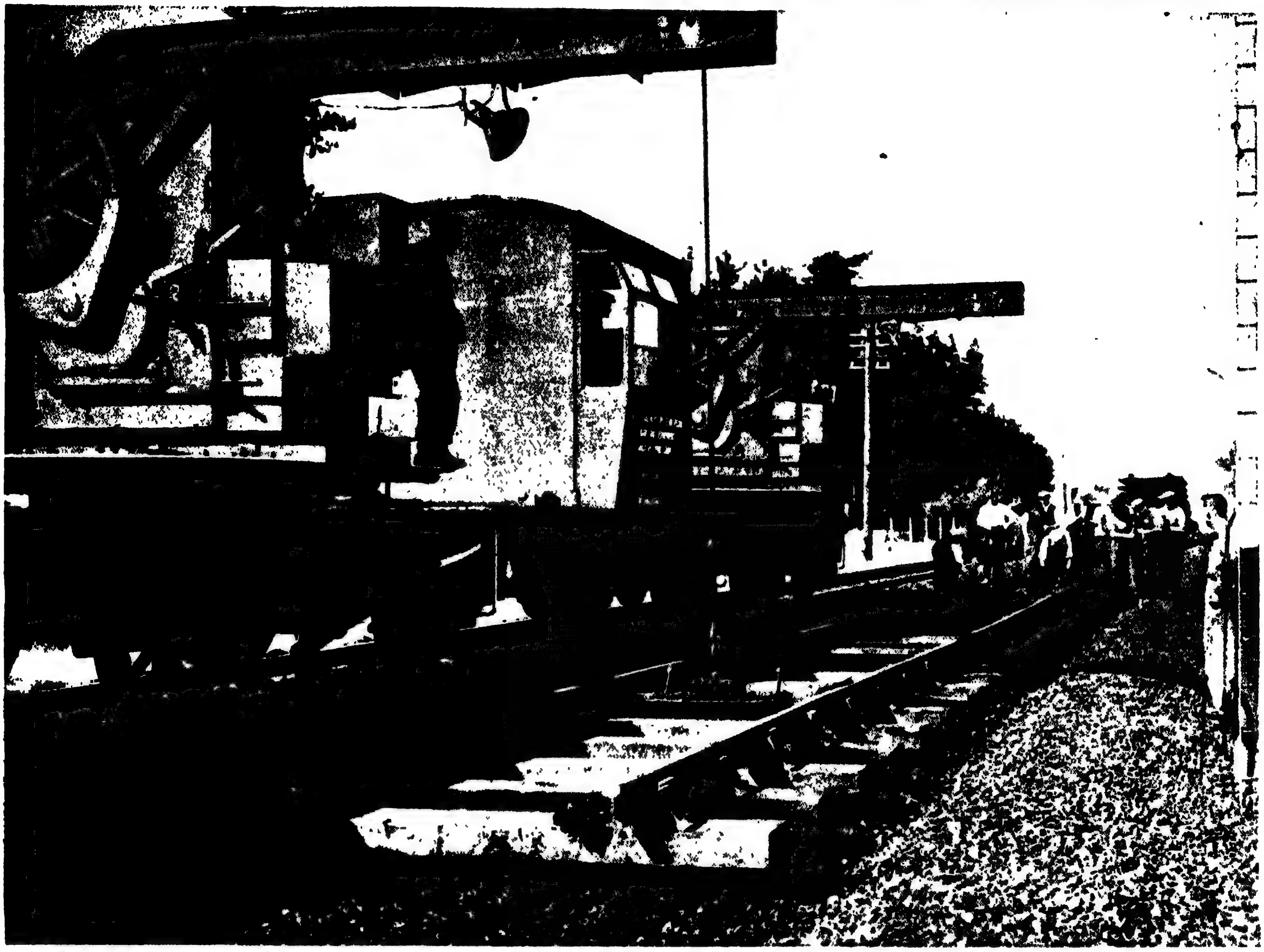


Fig. 6. Here all types of finished lamps are being tested before sale. A proportion are kept lit until they burn out, so establishing how long a lamp is likely to last.

LAYING A RAILWAY TRACK IN SECTIONS



This track-laying machine can place in position 240 yards of new line in an hour. The two cranes are controlled by one man from the cabin in the centre. Attached to the crane arms are powerful lights for track-laying at night

When railwaymen speak of a track mile they mean two lengths of rails each one mile long and laid parallel for the trains to travel on. Every track mile in Great Britain consists of 150 tons of steel rails made up of 176 single lengths of rail. One mile of track rests in 4,320 cast-iron chairs weighing a total of 87 tons and the rails are wedged into the chairs by either 4,230 wooden keys or 4,230 steel spring-clips. The 176 lengths of rail are joined to each other by 172 fishplates which together weigh 3½ tons, and the fishplates are fixed to the rails by 940 fishbolts weighing a total of ¾ of a ton. The chairs carrying the rails are attached to the sleepers by heavy bolts each weighing 1¼ pounds; as there are 12,960 of these bolts for every mile of track, their total weight is 8¾ tons. Rails and sleepers for a mile of track rest on 2,115 sleepers spaced 2½ feet apart and weighing 100 tons.

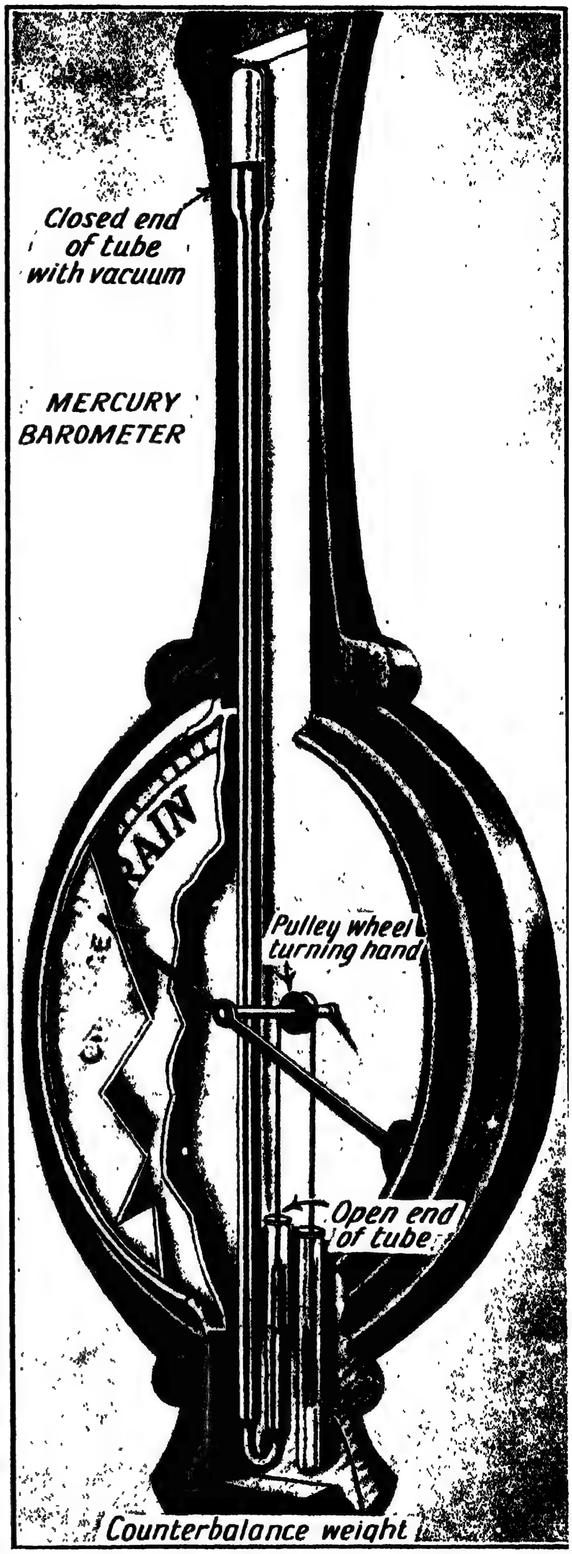
Every year British Railways have to re-lay approximately 1,650 miles of track, and much of this work has to be done with a minimum of interference to trains on busy lines. If all the components of a mile of track weighing 350 tons had to be assembled separately by hand the work would not only take a very long time, but traffic on the line would be seriously delayed.

So to lay new rails as quickly as possible track-laying machines are used. At the permanent way depot, sections of complete track are assembled, the chairs being spiked to the sleepers by automatic machines which fix two chairs to each sleeper at the rate of 120 sleepers an hour. The rails are then placed in the chairs and secured by the wooden keys driven in by a power hammer. The sleepers are of seasoned Baltic Red wood and are 8 feet 6 inches long, 10 inches wide and 5 inches deep.

Sections of track complete with rails, chairs, and sleepers in position and each 60 feet long are loaded on to a railway waggon and taken to the spot where they are to be put down. On a parallel set of lines is the actual track laying machine. This consists of a long waggon on each end of which is a steam crane with a fixed arm jutting over the line being re-laid. The crane waggon is drawn by a steam engine and begins work by running alongside the track waggon and lifting off a length of the made-up track. The crane waggon carrying the length of track, as shown in the picture above, is then pushed back to the end of the track being re-laid and lowers the section of line into position so that it joins the section previously laid. The two sections are then secured by fishplates and bolts. In this way it is possible to lay track at the rate of 240 yards an hour.

The type of machine illustrated above can be used only where there are two tracks, one for the rail-carrying waggons to rest on, and one along which the double-crane travels. Where a single line track is being laid, the Morris track-layer is used. This consists of a crane mounted in front of the track-carrying waggons, the whole train being pushed by an engine at the rear. The crane lifts a length of track from the waggon, swings round, and then lowers the length of track in front of it. As the sections of track are bolted together the whole train moves forward along the newly laid rails.

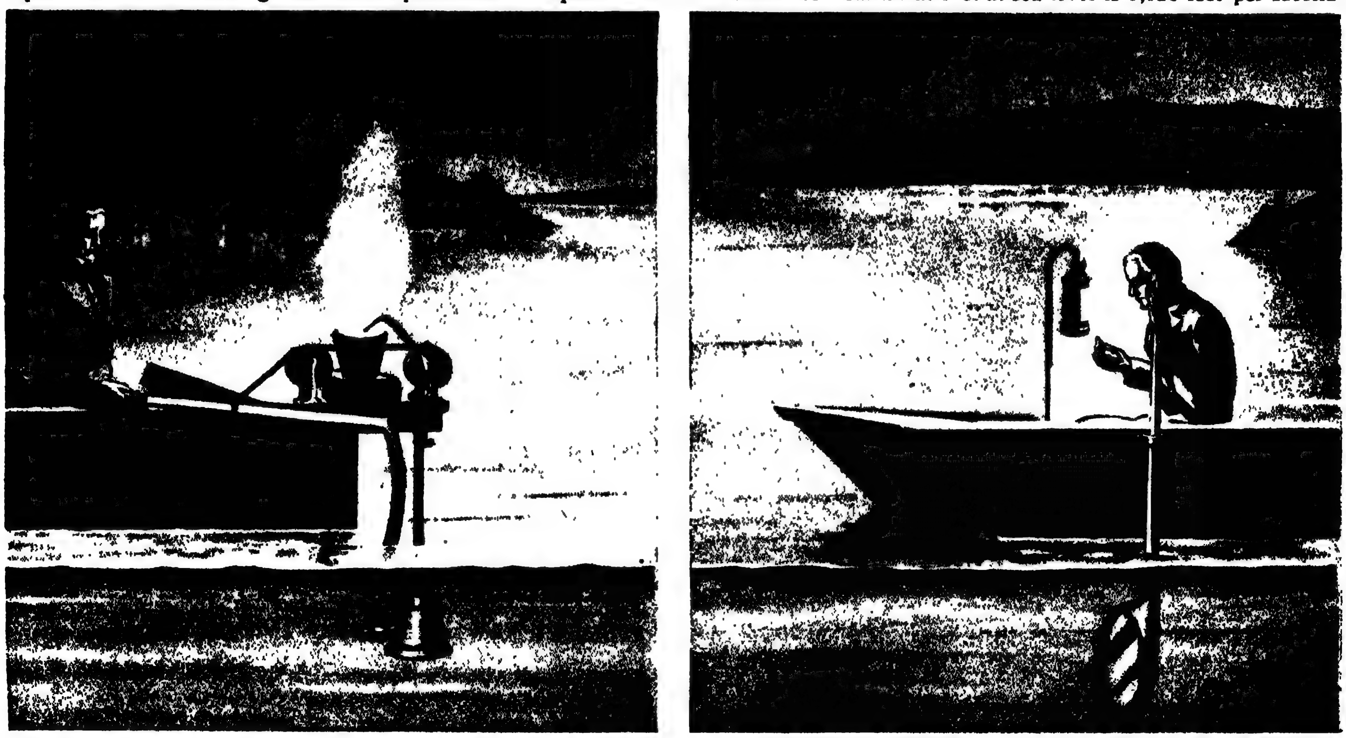
TORRICELLI INVENTS THE BAROMETER



It was Torricelli, a pupil of the great Galileo, who invented the barometer. Men had found that no pump would raise water higher than 32 feet above the level in a well, and Torricelli argued that if water would rise 32 feet, then mercury or quicksilver, which is about 13 times as heavy as water, ought to rise only one 13th as high. He tested this with a tube closed at one end, which he filled with mercury and inverted in a basin of the same metal. The column of mercury in the tube fell till it was only about 30 inches high, leaving a vacuum above it. Torricelli came to the conclusion that both the water and the mercury were supported by the outside pressure of the atmosphere. In this experiment he had invented the barometer. The modern mercury barometer is only Torricelli's tube with certain additions. A glass tube about 33 inches long, containing mercury, has its open end stood in a cistern of mercury, or has this end bent round. The air presses on the mercury in the cistern or the open end of the tube, and supports a column of metal about 29 or 30 inches high, according to the pressure of the atmosphere. A float in the open end of the bent tube has a cord passing over a little pulley, which turns a hand on a dial. Weather conditions depend upon atmospheric pressure, and can be more or less learnt by studying the barometer

MEASURING THE SPEED OF SOUND

Sound travels at different speeds through different substances and at different speeds according to the temperature and density of the substance and its height above sea level. One of the earliest measurement of the speed of sound was made over a century ago in France by two groups of scientists, each provided with a cannon and a stop-watch. The groups were stationed on low hills a distance of 61,047 feet apart. When one group fired the cannon, the other timed with its stop-watch the number of seconds between sighting the flash and hearing the sound. The time taken was $54\frac{3}{5}$ seconds. This gave the sound a speed of 1,118 feet per second. Later experiments with recording instruments prove that the speed of sound in calm and clear air at 0°C. at sea level is 1,120 feet per second



Sound travels more quickly through water than through air. This was proved in 1840 on Lake Geneva by two scientists named Colladon and Sturm. They were seated in boats one on the opposite side of the lake from the other. Sound was produced from one boat by striking a hammer against a bell under the water, while from the other boat a speaking trumpet was lowered. A sheet of metal was placed over the receiving end of the trumpet, and this vibrated when the sound waves transmitted through the water struck against it. The listener with the speaking trumpet held a stop-watch and knew the instant when the bell had been struck by observing a flash produced from the other boat by the firing of magnesium powder ignited by a lighted match attached to the hammer of the bell. The boats were 44,237 feet apart and as the bell sound passed between them in $9\frac{1}{4}$ seconds it was calculated that the speed of the sound through the water was 4,706 feet per second. A later experiment proved that sound travels more quickly through sea water than through fresh water. The accepted speeds are now 4,714 feet per second through fresh water and 4,990 feet through sea water. The speed of sound through water is the basis of the echo-sounding instruments, used for detecting the presence and distance of objects under the sea, described elsewhere in this book

WONDERS OF THE SKY

A MUSICIAN DISCOVERS A NEW WORLD

Many new discoveries are constantly being made in connection with the stars, and even new comets are found from time to time as astronomers scan the heavens. But the discovery of a new planet is an exciting event which occurs at very rare intervals. The excitement in the world of science when the planet Uranus was found by Sir William Herschel was enormous, and here we are told about the planet and its discovery

SOME of the greatest things in the history of the world have been done by men who were never specially trained for their tasks. King David, who delivered his nation from its enemies, was not a soldier, but a shepherd; Columbus, who discovered a new world far across the unknown ocean, had been trained, not as a mariner, but to some trade; Sir Christopher Wren, who built St. Paul's, was a professor of astronomy, not an architect by training, and Sir William Herschel, who discovered the first new planet for thousands of years, was an organist and a teacher of music.

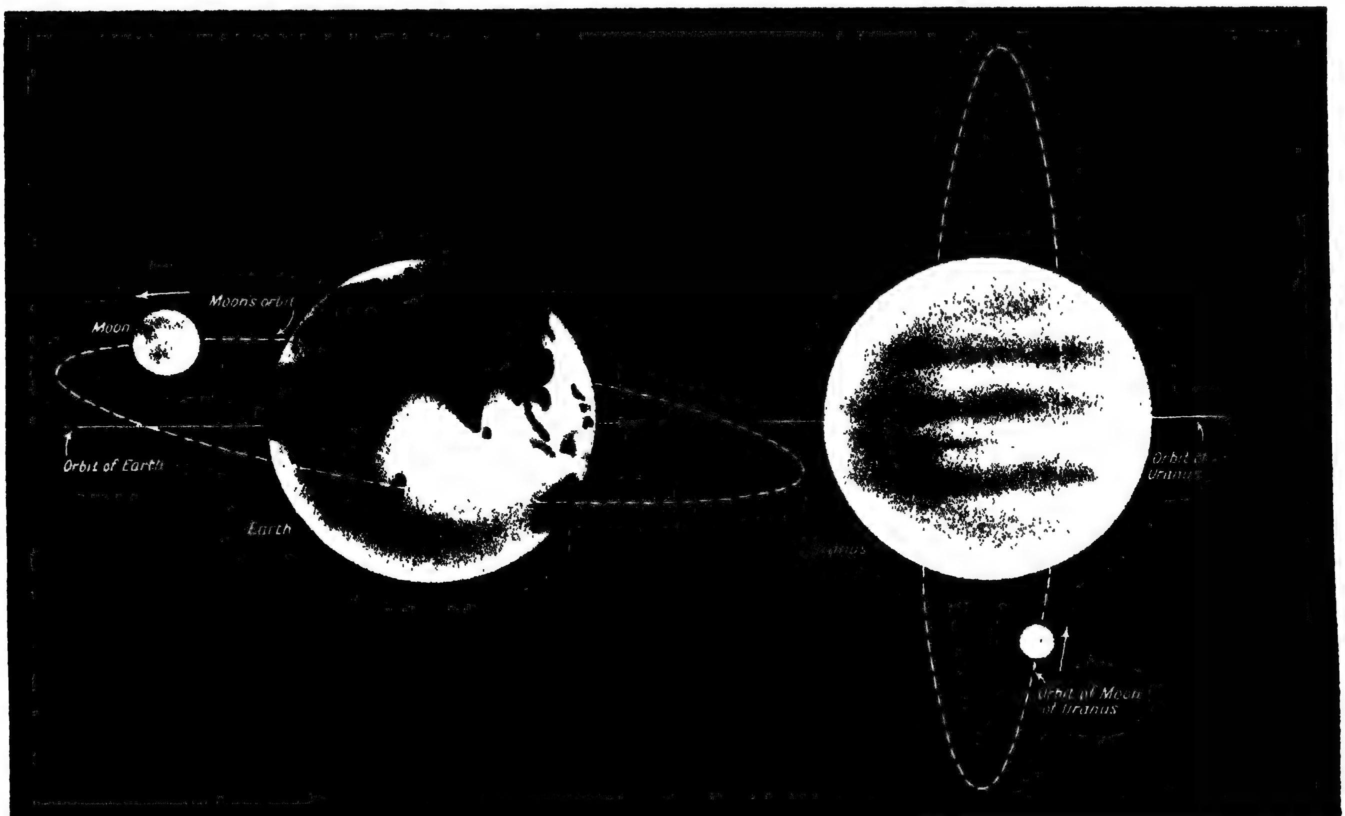
these days we are so used to zing discoveries in all fields of ice that we should hardly be rised at anything the astronomers might tell us. Indeed, when in March 1930 a new planet belonging to the solar system was discovered far beyond Neptune, with the exception of a few paragraphs in the newspapers the astonishing news attracted little popular attention.

Of course, scientists were interested to know that our solar system, of which Neptune up to then had been supposed to be the outermost member, had been extended by something like 2,400 million miles. They had, however, thought it quite likely that there might be still another member of the Sun's family which had not yet been found, just as when Neptune was discovered its position had already been worked out by mathematics, before it had been seen.

Things were very different, however, at the end of the eighteenth century, when Herschel discovered Uranus. At that time it was thought that practically everything important was known about the objects in the heavens, and certainly about the solar system. The planets Mercury, Venus, Mars, Jupiter and Saturn had been known from the most ancient times, and no one supposed there could be any more planets to discover.

When, therefore, on the night of March 13th, 1781, William Herschel, the Director of Public Concerts at Bath, looking through the new telescope which he had made himself, saw a strange object that could not be a star, it never occurred to him that it could possibly be a planet. He knew it was not a star, for the telescope showed the object distinctly as a disc, and stars appear only as points of light.

He thought therefore it must be a comet, and in reporting the matter to the Royal Society he headed his paper "An Account of a Comet," and said,



Uranus, the planet whose path lies between the orbits of Saturn and Neptune, was discovered by Sir William Herschel while he was a professional musician. It is a very strange world, for it appears to rotate on its side, as it were, and its four moons revolve round it at right angles to its orbit. In this picture the Earth and Uranus are compared. Of course neither the planets nor their moons nor the orbits of the moons are drawn to scale. The picture is merely to show the strange way in which Uranus and its moons go round

"On Tuesday the 13th of March, between ten and eleven in the evening, while I was examining the small stars in the neighbourhood of H. Geminorum, I perceived one that appeared visibly larger than the rest; being struck with its uncommon magnitude I compared it to H Geminorum, and the small star in the quartile between Auriga and Gemini, and finding it to be so much larger than either of them, suspected it to be a comet"

Giving a Planet a Name

The astronomer mentioned, however, as a strange fact, that this comet seemed to move like a planet. Yet even then no one had the idea that it could really be a planet, and it was some months before its true nature was first hinted at, and then proved, by an astronomer of St. Petersburg, now called Leningrad.

Herschel, as the discoverer, had the right to give the new world a name, and he suggested Georgium Sidus, in honour of King George III The words mean the George Star. No one liked this name, and a French astronomer tried to get it changed to Herschel, after the discoverer, but in the end it was given the very suitable name of Uranus, which in the old mythology was the name of Saturn's father.

It is interesting to know that this discovery was the turning point in Herschel's career, for it transformed him from a music master into a great astronomer. He was appointed Private Astronomer to George III, and was now able to devote himself entirely to the study of the heavens, instead of, as was formerly the case, getting very little time for his favourite hobby.

In the old days between the Acts at the theatre at Bath, he used to be seen hurrying from the harpsichord to his telescope for a peep at the sky, and then back again.

Since that time a good deal has been found out about this planet, but even now we know far less than we do about such planets as Mars and Venus and Saturn and Jupiter.

Uranus travels round the Sun in an elliptical path, and the Sun is 83 million miles out of the centre of this orbit. The mean distance of the planet from the Sun is 1,782 million miles, and it takes 84 years to go round the Sun once; in other words, its year is equal to 84 of ours. In making this journey it moves at the rate of 372 thousand miles a day, or less than a quarter the speed of the Earth. It turns on its axis, but we do not know the exact length of its day. The light and heat it receives from the Sun are about one 370th of that received by the Earth.

A World with a Green Face

When seen through the telescope Uranus shows a rather greenish disc with some indication of bands, and measurements show its diameter to be about 28,500 miles. It used to be thought that the diameter was several thousand miles more than this.

The volume of the planet, that is, the space it occupies, is believed to be 47 times that of the Earth, and the mass, or amount of matter in it, about 14½ times that of the Earth. The planet is considerably flattened, more so than the Earth.

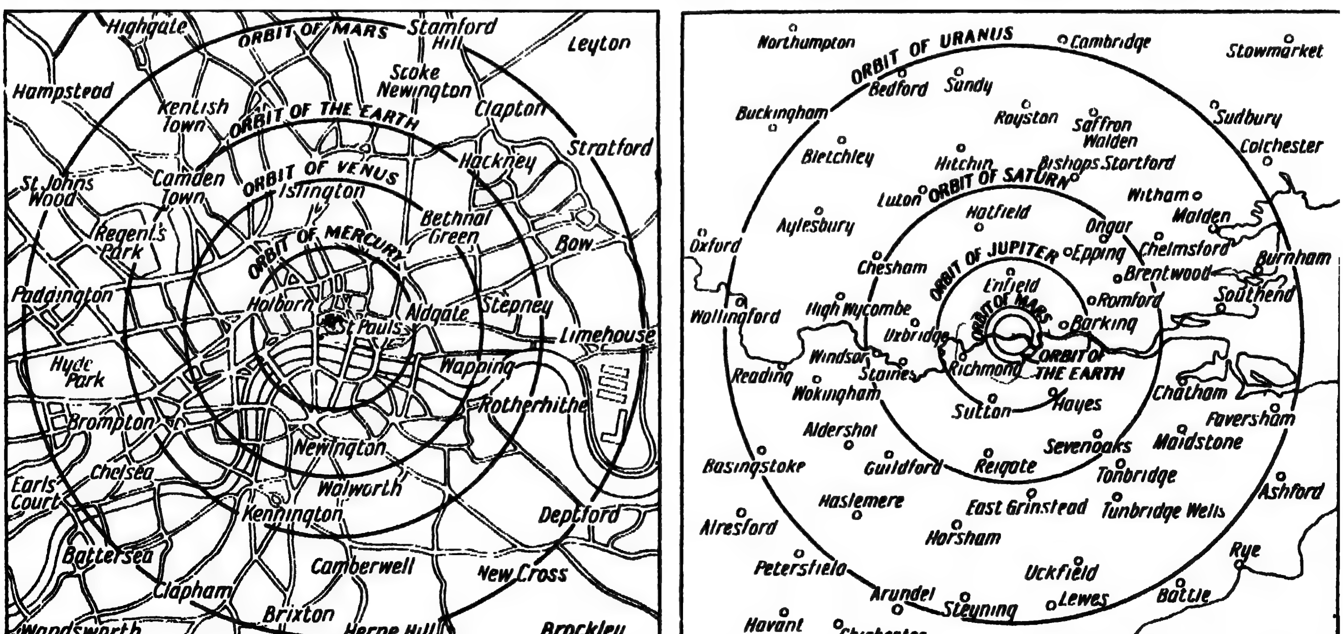
But the most interesting thing about Uranus is its moons, of which there are four. These have been given the names of Ariel, Umbriel, Titania and Oberon. Two of these, Oberon and Titania, were discovered by Sir William Herschel a few years after his discovery of the planet itself; the other moons were discovered in 1851.

Moons Travelling in Strange Orbits

The interesting thing about them is that they move round the planet, not like our Moon and the moons of other planets, more or less in the plane of the planet's orbit, but at right angles to the orbit. This suggests that Uranus itself is, as it were, on its side. It is very mysterious, and astronomers are unable to tell us why this should be.

If any inhabitants were living on this distant planet the strange position in which it turns on its axis would have a very extraordinary effect, for in its year, that is, during the time it is going once round the Sun, each pole would have 42 years, according to our reckoning, of day and sunshine when it was turned towards the Sun, and 42 years of night and darkness, without any day, when it was turned away from the Sun. Imagine what this would be if our Earth were in the position of Uranus. Many people who happened to be born on the side opposite to the Sun would grow up and live and die without ever seeing daylight.

THE PLANETS' ORBITS IF ST. PAUL'S WERE THE SUN



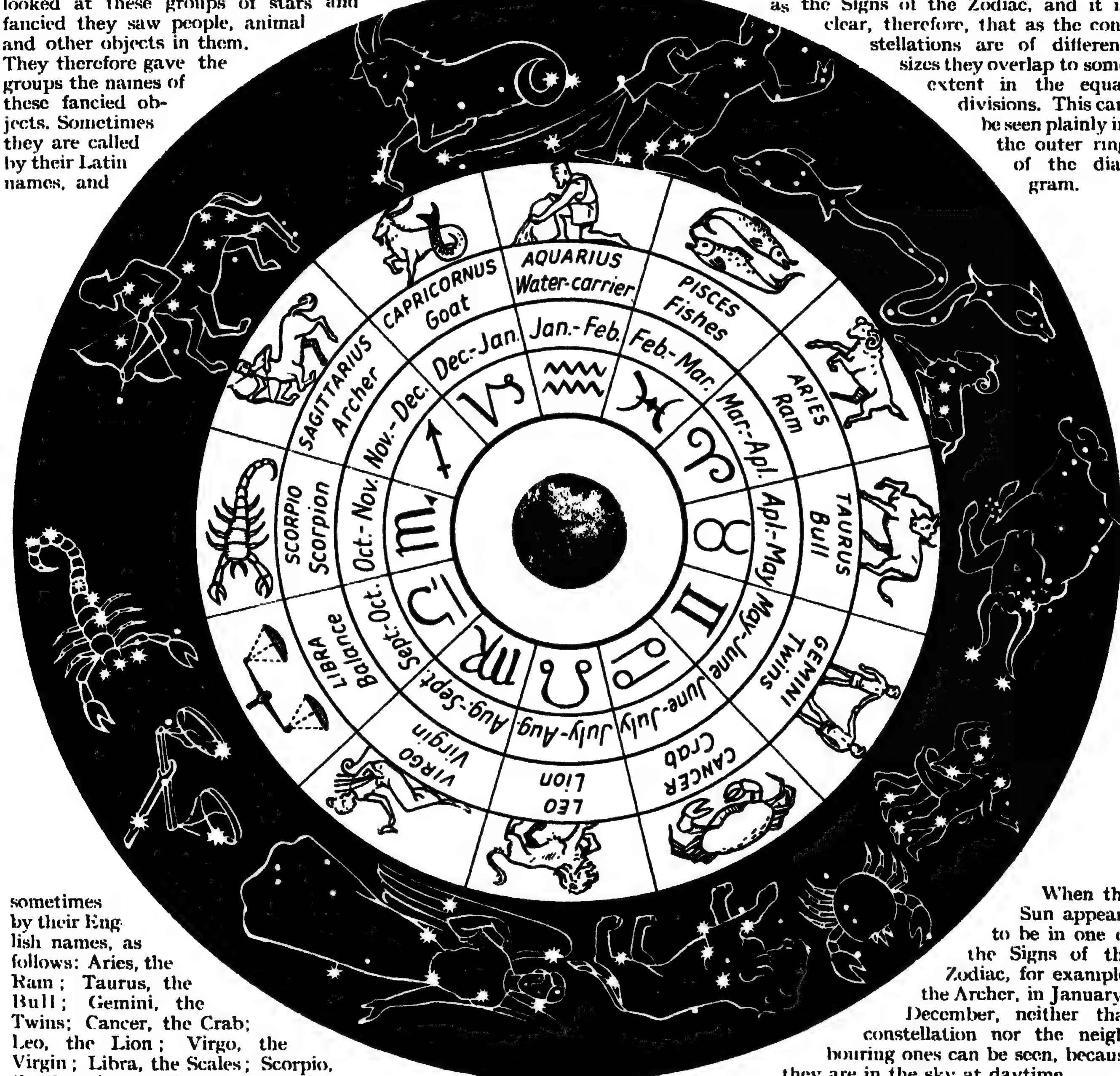
In order to get some idea of the relative distances of the planets from the Sun we may imagine that the dome of St. Paul's represents the Sun. Then the orbits of the four planets nearest to the Sun would be in the positions shown in the left-hand map. These circles round London, however, would be only one 40-millionth of the real orbits, just as the dome of St. Paul's is only one 40-millionth of the diameter of the Sun. To get an idea of the relative distances of the farther planets, Jupiter, Saturn and Uranus, we need to take in far more country, and we see this in the right-hand map The orbits of Neptune and Pluto, which are very much farther off, are not given

THE SIGNS OF THE ZODIAC AND THEIR STARS

VERY early in the history of man it was noticed that the Sun in its annual journey seemed to pass across a band of the heavens in which were twelve groups of stars. These groups of stars we call constellations, a long word from the Latin which simply means " stars together."

Just as we look into the fire and fancy we see pictures, so the Ancients looked at these groups of stars and fancied they saw people, animal and other objects in them. They therefore gave the groups the names of these fancied objects. Sometimes they are called by their Latin names, and sometimes by their English names, as follows: Aries, the Ram; Taurus, the Bull; Gemini, the Twins; Cancer, the Crab; Leo, the Lion; Virgo, the Virgin; Libra, the Scales; Scorpio, the Scorpion; Sagittarius, the Archer; Capricornus, the Goat; Aquarius, the Water-Carrier; and Pisces, the Fishes. There is a simple rhyme which will help us to remember them.

> The Ram, the Bull, the Heavenly Twins,
> And, next the Crab, the Lion shines,
> The Virgin and the Scales;
> The Scorpion, Archer and He-goat,
> The Man that has the Water-pot,
> And Fish with shining scales.



The constellations of the Zodiac, with their principal stars and their symbols

In the picture on this page we see the various constellations, but it is difficult for us to recognise any likeness in them to the objects named. We see also the usual kind of picture which represents each constellation, the names in Latin and English, the date on which the Sun is in each constellation, and some queer signs which are often used to save the trouble of giving the full name or drawing a picture. These are a kind of hieroglyphic, and in some of them we can see a rough resemblance to what they represent, as, for example, in the two strokes representing the twins, the wavy lines representing water, and the arrow for the archer.

The twelve constellations that have been named form a narrow zone or band round the heavens, and this is known as the Zodiac, from two Greek words which mean " the circle of little animals." The band is divided into twelve equal parts, which are known as the Signs of the Zodiac, and it is clear, therefore, that as the constellations are of different sizes they overlap to some extent in the equal divisions. This can be seen plainly in the outer ring of the diagram.

When the Sun appears to be in one of the Signs of the Zodiac, for example, the Archer, in January–December, neither that constellation nor the neighbouring ones can be seen, because they are in the sky at daytime.

It is supposed that there are references in the Bible to the Signs of the Zodiac, some scholars thinking that Mazzaroth in the 38th chapter of Job, verse 32, refers to this band of constellations, and the reference to the Sun's circuit in the 19th Psalm, verse 6, is also regarded as a reference to the Zodiac. The men of the Bible were, we know, great students of the heavens

THE GORILLA IN ITS NATIVE HOME

The gorilla is the largest of all the man-like apes, and it is a very powerful creature. Hunters tell us that a full-size male gorilla would be more than a match in physical strength for ten men. Hundreds of years ago there were stories of a large ape that inhabited the African forest, but few scientists credited the stories, and it was only when a French traveller, Paul de Chaillu, came back from the Dark Continent in 1861 and told how he had actually seen the gorilla, that anything definite was known about it. Even then for some years people believed he was telling fairy-tales. The gorilla reaches a height of nearly six feet and weighs as much as thirty stones. Its footprint is three times the size of a full-grown man's. This fine photograph, showing it in its native haunts, is from the film "Congorilla"

A GIANT AMONG THE MONKEYS

The gorilla, the largest of the man-like apes, was believed to be a myth up to the middle of the nineteenth century, but then a French traveller returned to Europe from Africa and told how he had seen the gorilla in its native haunts. It was not till the present century, however, that live gorillas were photographed in the Congo forests and living specimens actually brought to Europe. The gorilla becomes a more interesting creature the more its life and habits are known. Here we are told many interesting things about this giant among the apes

The Gorilla is the giant of the man-like apes. Not only does it reach the height of six feet, but its massive size and muscular development make it look a monster indeed In the course of the ages it has developed brute strength and mass of body, and its strength of jaw and limb are almost incredible. An average specimen has the strength of at least five men, and there are some gorillas which could overcome ten men.

Though very small when born, being less than half the weight of a new-born human baby, the adult male weighs as much as two full size men. One old male which was shot in the Eastern Congo weighed over 32 stones and ten men were required to lift its carcass

In the proportions of its arms and legs to its body, the gorilla is nearest of all the apes to man, but it has a brain no larger than a four-year-old child Its hairy coat consists of blackish or blackish-red bristles with an under-fur, and it becomes grey with age. The face is naked and black, but the head is crowned by reddish hair. It is certainly not a pretty-looking animal, for it has a huge protruding mouth, broad and flat nostrils and eyes overhung by bony ridges When it opens its mouth it shows a set of very formidable teeth.

A Dying Species

The gorilla is certainly an interesting animal, but unfortunately, like so many interesting animals, it is dying out. Sir Arthur Keith declares that if we estimate the total gorilla population at 50,000 he feels sure we have exaggerated. In any case, if all the gorillas in the world were gathered together they could be accommodated in one of our small country towns.

The animal is found in the great Equatorial forests of Africa, and it lives in the hilly jungle country, although it is fond of coming down into the clearings which men have made and forsaken.

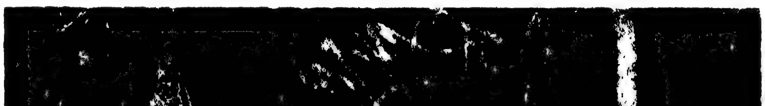
Bands of gorillas often make marauding expeditions to the native plantations and play havoc with the plantains and sugar-canes, the young shoots of which they like. They eat a great deal and feed chiefly on the bamboo shoots and succulent roots.

They are never found farther north than the Cameroons or farther south than the mouth of the Congo. They were first discovered in the middle of the nineteenth century by the French traveller Dr. Chaillu, but at the beginning of the present century in the volcanic mountains to the west of Lake Kivu, another race of gorillas was found, more hairy and stocky in build than the West African kind.

Gorillas are found living at a height of as much as 10,000 feet above sea level. They go about in small bands of about ten which seem to be families, each band being led by a massive male, two or three adult females, and a number of younger animals.

While the gorilla is so powerful and is a formidable foe if called upon to defend its family, the stories about gorillas seeking out and pursuing human beings and carrying off people have no evidence to support them.

The male gorilla is a fearless animal, and though it usually moves about on all fours it will stand up to face a foe. Mr. Ben Burbridge, the well-known hunter, says it is doubtful if an adult gorilla muzzled could be overcome by a dozen trained prize-fighters Even baby specimens need two or three men to master them. A gorilla fears no one except perhaps a man with a gun. It can seize a leopard, maul it to death and toss it aside as though it were a kitten



Although the gorilla, when facing a foe, will stand upright, its usual attitude when moving about is on all fours, as shown here, and while walking the fingers of the hand are usually doubled on to the palm, but the whole sole of the foot is placed upon the ground. The animal can, however, walk with its fingers extended and its toes bent down on the sole of its foot

A Bed of Branches

At night the old male gorilla makes a bed of branches at the foot of a tree where it sleeps, but the younger animals and the females generally spend the night on rough platforms built up in the trees. The male gorilla is too heavy to go up.

The gorilla makes two sounds that greatly impress all travellers. One is a fearsome roar, and the other a loud drumming caused by the thumping of the chest with the fists. Before flight gorillas always pause in the forest and roar and beat their chests.

Describing these sounds, Mr. Burbridge says: "Then came a deeper

THE GORILLA FACES MAN IN THE CONGO FOREST

Up till recently, although the living gorilla had been seen in the forests of Africa, it had never been photographed alive. Now not only has it been photographed, but moving pictures of it have been taken in the Congo, and people who stay at home can see the animal just as the intrepid hunter sees it. In this still from a cinematograph film the great and powerful animal is looking out at the cameramen as they take their picture of him

Unlike most wild animals, the gorilla roams the forest in search of food during the daytime only, and at night it goes to rest just as human beings do. The gorillas construct a kind of nest in the trees by bending the boughs together and covering them with twigs and moss. This nest is made several yards above the ground, and in it the female and the young pass the night, while the male gorilla takes his place at the foot of the tree, where he remains in a sitting posture ready to protect his family from the attacks of leopards and other enemies. This photograph shows two young gorillas that were surprised by the camera

boom—a dull, resounding, rapid striking, a muffled drumming which carried with it a certain sense of power. It was like the sound of strong men rapidly beating a carpet. A terrific roar filled the forest's silence. Again and again it crashed, deep and guttural in answer to the echoes that were flung backward and forward among the assembled peaks. In the accompanying silence it came to me that down there, beyond the leafy screen, an old man gorilla was looking up at us and voicing in his roars and chest-beats the ape's ancient defiance of humankind as old as Africa. Some observers have likened the roar of a gorilla to a bark This is true of the animal when pursued, but at bay the vocal utterance is prolonged and tremendous. It rivals even the roar of a lion"

The Crash in the Thicket

Mr. Burbridge, who spent a long time in Africa trailing the gorilla, followed a band and arranged his camera ready to photograph the animals. Suddenly a violent crash in the thicket, like the rapid explosion of giant fire-crackers was heard, and up out of the green, thirty feet away, appeared a great gorilla. "For a moment," says Mr. Burbridge, "he sat there transfixed, one huge fist closed around the branch of a tree overhead. Then with slow deliberation he raised himself higher, craning his neck to see over intervening thickets, a half human, half brutish thing silhouetted against the gloomy forest. His wrinkled old face framed in bristling hair, expressed intense curiosity.

An Angry Animal

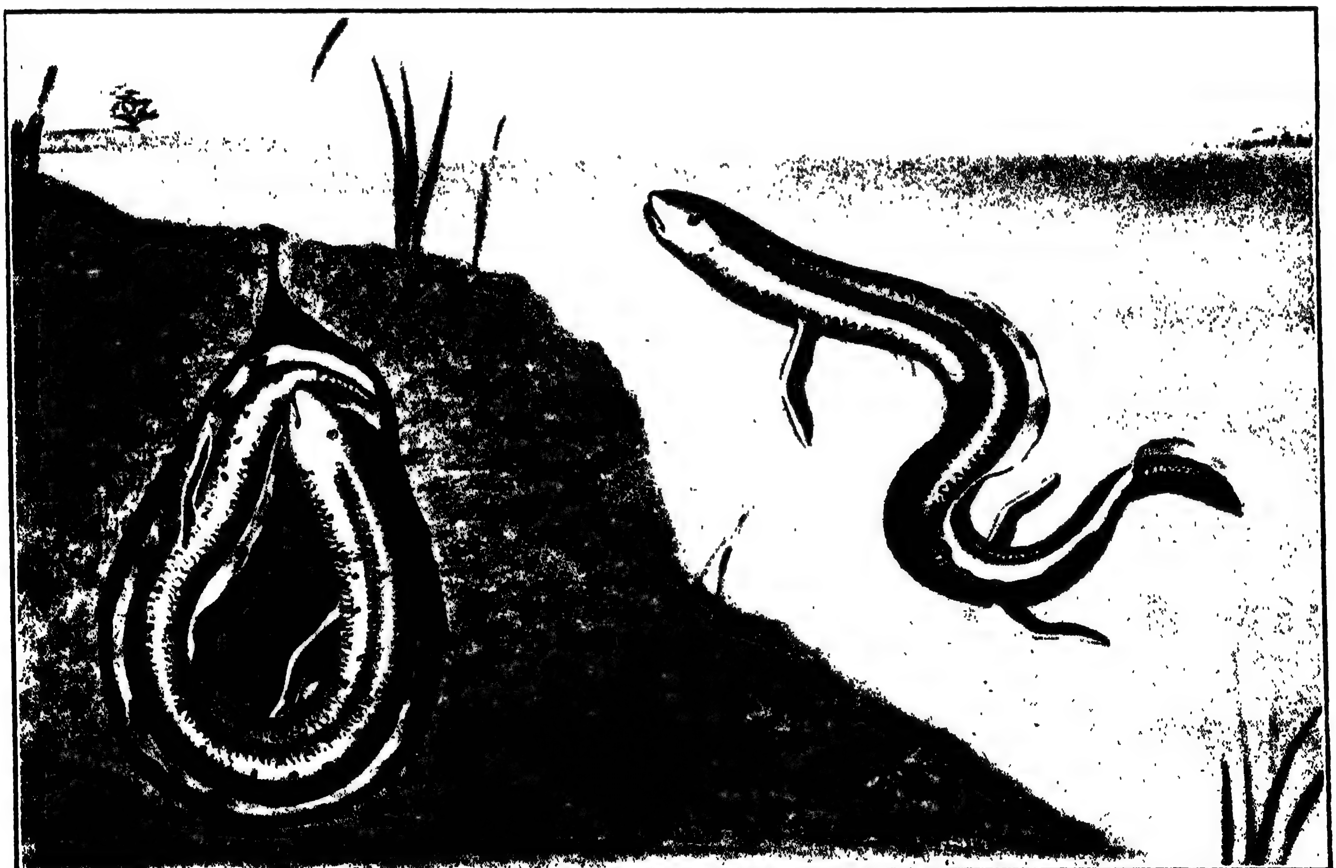
"It was a strange introduction, the presentation of these two—white man and gorilla, out there in the Congo forest. The ape, so manlike, seemed gazing from a gloomy cavern impersonating the Stone Age in a meeting with the steel.

"The sudden movement of another gorilla just below him and screened from sight caused the first gorilla to look down. Perhaps some word passed between them, for as he jerked his head toward me a fit of passion convulsed his face. The cavernous mouth opened and a tremendous roar filled the forest. With sudden tremendous power he tore a limb from the tree and carried it to his mouth, biting off chunks of the hard wood and spitting them out. I sprang up to swing the motion-picture camera upon him, but he dropped from sight into the jungle masses and was gone."

Like the chimpanzee and the orang-utan, the gorilla does not habitually walk erect, but supports itself with its hands, which are usually partly closed so that the weight is borne on the knuckles. In the trees these animals move with surprising speed and agility, and can take long leaps that would appear impossible for such heavily built animals. Owing to its great muscular development and savage disposition, it is a very formidable opponent when brought to bay, but the stories of aggression on its part appear to be ill-founded. It rather avoids encounter with man, and makes off with great speed on his approach.

It is difficult to keep the gorilla in captivity. Young specimens exhibit some docility for a time, but soon mope and die. Adults can be tamed but unless expertly managed quickly die. Several gorillas have been kept in the London Zoological Gardens, but they seldom lived for long.

THE LUNG-FISH GOES TO SLEEP FOR THE SUMMER



In Africa, South America and Australia there live fishes which are known as lung-fishes, and these have the strange habit of going to sleep for the summer. Just as the winter sleep of animals in cold climates is called hibernation, so this summer sleep has been given the name of aestivation, from the Latin word for summer. The lung-fish, when the hot weather comes and the waters in which it usually lives begin to dry up, retreats to the mud at the bottom and forms a chamber in which it curls up and goes to sleep. Gradually the river or lake dries completely, and the fish is left in a dry chamber. Sometimes the hard mud has been dug out with the fish in it and sent to Europe in a tin box, and there the mud has been soaked in water and the fish has awakened and become active once more

THE GREAT POWER OF A GROWING PLANT

The power which a plant has to grow is very remarkable. Of course, it must have suitable conditions and adequate food of the right kind, but, given these, it will grow healthily till it attains full size. If anything is in the way of its growth it will either take another route and grow round it, or push it out of the way Toadstools have been known to lift paving stones, and growing trees to split marble tombs. In the example shown here of a laburnum tree, the branch, when tender, grew in and out of the railings, and then, as it became stronger, lifted the railings bodily out of the ground, an interesting illustration of the power of a growing plant. The rate of growth of some plants is also very astonishing. A certain bacterium, the lowest form of plant life, produces two similar individuals in half an hour, and if the resulting plants survived and went on multiplying at this rate, it has been calculated that 16½ millions would be produced in 24 hours, and in a few days the mass of bacteria from the single plant would be greater than the size of the whole Earth

WHY LIVING PLANTS DO NOT DRY UP

A LIVING plant contains a very large proportion of water. Generally about three-quarters of its weight is water, and therefore large quantities of water must pass through the plant so that the food solution in the soil on which the plant feeds may be carried to the leaves.

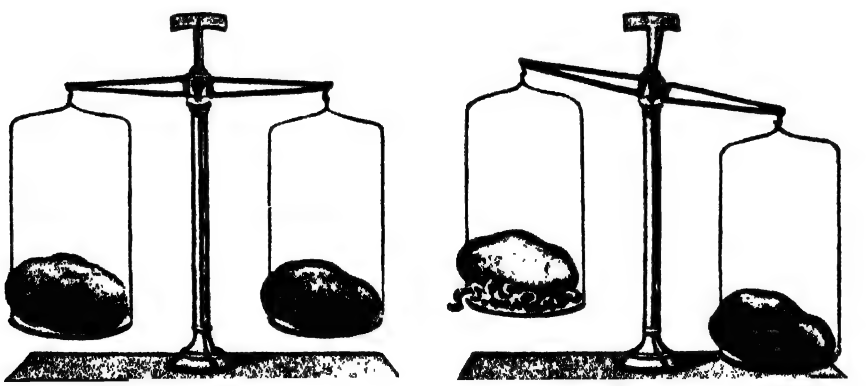
The plant gives off water from its leaves and growing shoots, or in other words it perspires, and it is in this way that the constant stream of water is kept passing through the plant. But a plant must not perspire too rapidly, or it will perish, and it is to protect the plant from the excessive evaporation of the fluids within, that the outer bark or skin exists.

Most trees are provided with a layer of corky cells which serve this useful purpose, and other parts of the plant also have a protective covering. How valuable this covering is can be proved by a simple experiment which we can carry out if we have an accurate pair of scales.

We take two potatoes of equal weight, testing this by putting them in the two pans of the scales. Then we take one of the potatoes and pare the skin from it. We put this potato back into the pan of the scales, together with the peelings. It still weighs the same as the other potato.

But we shall find if we leave it in the pan it will very soon begin to lose weight and the other potato will weigh it down. The loss of weight is due to the rapid evaporation of the potato's moisture, which goes on directly its outer covering is removed, and in a few days it will be very dry, its weight being much less.

The passage of the water up the stem of a plant is through the woody tubes which men of science call fibrovascular bundles. "Fibrovascular" is a difficult word which simply means "fibres made up of little vessels."



Two unpeeled potatoes of the same weight in a balance. When one is peeled it begins to lose moisture as shown on the right

A GREAT SCENE ON A LITTLE ISLAND

Magna Carta is the greatest charter of English liberty in the nation's history. The way in which at the beginning of the thirteenth century all classes of Englishmen combined to wring justice from a mean tyrant is a story full of thrilling interest which is told here with vivid detail

When Richard of the Lion Heart died in France from the effects of a poisoned arrow wound there was some doubt as to who would mount the English throne. The rightful heir was Prince Arthur of Brittany, the son of Richard's brother, Geoffrey, who was dead, but he was only eleven years old. John, a younger brother of Richard and Geoffrey, determined to make himself king, and he seized the royal treasure and sent emissaries to England to win over the barons there.

Those were rough days, and the English barons chose the grown-up uncle in preference to the youthful nephew, believing that he would make a better leader for them.

But John holds the distinction, if such it can be called, of being the very worst king that England has ever had. To-day it would be difficult if one searched the annals of all nations to find any other ruler so utterly despicable as John. Possibly it is on account of this reputation that we have never had a second King John.

The Foundation of Liberty

Yet it is a fact that in John's reign the very corner-stone of the foundation of English liberty was laid. This, of course, was not due to any virtue on the part of John but to his vices. In sheer desperation all parties and classes combined for the very first time to resist the monstrous extortions and oppression of the mean-spirited tyrant on the throne.

John started by murdering his nephew Arthur with his own hands. The crime roused the indignation of the people of Brittany, and with the aid of the French, Normandy was invaded and several of John's castles captured. John disgusted his followers with his slothful indifference, feasting and amusing himself daily instead of resisting the enemy, and when he heard of disaster after disaster at the hands of the French king all he could say was "Let him alone. I shall one day win back all that he is taking from me now."

When at last nearly all his dominions in France had been captured by Philip, the French king, he became greatly upset and, we are told, cried and groaned.

Hubert, the Archbishop of Canterbury, died, and John now quarrelled with the Pope about his successor. The Pope appointed Stephen Langton to the vacant see, a thing he had no right to do, but nevertheless Langton was a splendid man for the post, and although appointed by the Pope he always showed himself a patriotic Englishman, standing up for the rights of his country.

John was so angry that he forbade Langton to enter the country, and the result of the quarrel was that the Pope laid the country under an interdict. This meant that all religious services were forbidden, churches were shut up, no sacraments could be performed except the baptism of infants, no last rites celebrated for the dying, and that marriages had to take place in the churchyard instead of inside the church, and the dead had to be buried in roads and ditches without prayers. This was all very terrible to the people in John's day, for religion played a much larger part in the nation's life then than it does now, and anything like the withholding of religious consolation caused fear and terror.

The Barons swear to defend themselves against King John

In order to keep a hold upon his nobles, John compelled them to give up to him their sons and nephews as hostages, and many of these he killed.

He badly wanted money, so determined to squeeze it from the Jews, and he had all the people of that race throughout England, young and old, male and female, seized and imprisoned, and where they would not give up their money they were tortured.

One of them, the Chief Rabbi of Bristol, although dreadfully ill-treated, refused to give up anything, whereupon the king ordered his agents to knock out one of the rabbi's teeth every day until he paid 10,000 marks of silver. Each day, for seven days, a tooth was knocked out, and then the poor man's agony was so great that as soon as they started the operation on the eighth day, he reluctantly provided the money demanded.

John went from bad to worse, and then the Pope excommunicated him. This meant that John was cut off from the fellowship of the Christian Church, and when that happened a king's subjects no longer owed him allegiance and he could be deposed. People were afraid to sit at the table of an excommunicated man or even to speak to him, and John now began to think he had gone too far, especially when the Pope announced that he would depose John and would transfer the crown to his old enemy Philip, King of France. John could not depend on his own warriors if a French army came into England, and he therefore decided to submit to the Pope. In doing this he brought the country to a condition of abject humiliation which it has never suffered before or since.

The Legate Arrives

The Pope sent a legate named Pandulph, and to him, on behalf of the Pope, John handed over his kingdom, a thing he had no right to do, and agreed to hold it as a vassal of the Pope.

No humiliation was spared in the ceremony before the legate. John entered his presence unarmed, flung himself on his knees before the throne on which Pandulph was seated, and lifting up his joined hands, put them within those of the legate, swore fealty to the Pope and paid tribute. It is even said he laid his crown at the legate's feet.

One good result of John's submission to the Pope was that Stephen Langton, the Archbishop of Canterbury, was now able to come into England and perform his duties. He became a great and inspiring leader, and it is largely to him that we owe that great landmark of our liberties, the Magna Carta, or Great Charter, of which we shall now hear.

John continued his oppressions and extortions and cruelties, and at last things became so unendurable that the barons decided that something must be done to curb the wicked king. It was at this point that Archbishop Langton showed them a charter granted by King Henry the First, and caused it to be read aloud to them, granting to his people certain laws and liberties. The barons thereupon swore that they would insist on those liberties and if need be fight for them. Henry's charter was to be treated as a basis for much-needed reforms.

Their representative, Geoffrey Fitz-Peter, laid these claims before John in London, but when, soon afterwards, Geoffrey died, the king exclaimed with glee: " Now by the feet of God I am for the first time king and lord of England." The king rarely spoke without a strange oath. John then went to France and attacked the French king, but after the severe defeat of his allies he was compelled to return to England, a disappointed man to the Pope and eight other persons, four of whom he was to choose, while the other four were to be selected by the barons.

The time had gone by, however, for anything of this kind, and now without further parleying the barons openly threw off their allegiance and began to attack various royal castles. Then they entered London, where the citizens opened their gates readily and received the armed forces with great enthusiasm.

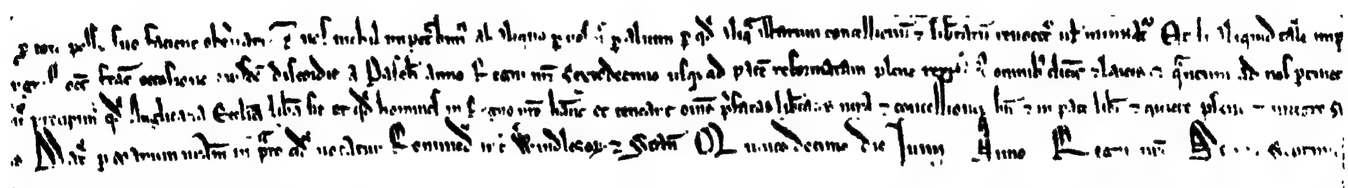
John Loses His Friends

Other cities followed the same example, and John's supposed friends and followers began to fall off, till at last, we are told, he was left with only seven knights, who were his sole supporters. The commander of the barons' army was Robert Fitz-Walter, who was given the title of " Marshal of the Army of God and the whole Church."

It must be remembered that the barons were really fighting for their own cause and not for the liberties of the people of England as a whole, but firmness and determination of the barons, but more so by the armed force which he knew was at their back, surrendered and agreed to the demands set forth in a list of forty-nine articles drawn up in detail on the spot. Wax was at hand, and the barons, leaving nothing to chance, insisted on the king sealing the document with his Great Seal.

We often read about John signing Magna Carta, and there are paintings showing the king putting his name to the document with a quill pen. But that, of course, is nonsense. He could not write. No king of England could write before Richard the Second. Magna Carta was not " signed " at Runnymede, but " sealed." It is said that the actual sealing took place on a little island ever since known as Magna Carta Island, lying off Runnymede.

This famous document you may see in the British Museum. It is in a running hand and seems to have been written very quickly, though carefully, as the discussions proceeded. An



The last words of Magna Carta, given here in facsimile, by courtesy of the British Museum. The last line translated reads: " Given by Our hand in the meadow which is called Runnymede between Windsor and Staines on the Fifteenth day of June in the Seventeenth year of Our reign." The Charter was sealed, not signed, because John could not write

Nearly all the barons of England were now joined together in their determination to make John restore their ancient liberties, and they decided that they would draw up a great charter, and unless the king sealed it with his own seal they would make war upon him. John tried to sow jealousy among the barons and the clergy, but he failed, and after receiving a deputation from the barons in which they repeated their claims, the king asked for a truce for about three months.

The Tyrant Begins to Tremble

Again the barons met, this time with their arms, at Brackley, in Northamptonshire, and prepared their claims for presentation to the king, who was at Oxford.

They came before him and said: " These are our claims, and if they are not instantly granted our arms shall do us justice." The fury of the king was terrible to see. " Why do they not demand my crown also ? " he cried, and then with a great oath he added, " I will not grant them liberties which will make me a slave."

However, the feeling against the king was spreading even to the poorest people, and the tyrant now began to tremble not only for his throne but for his life. In order to gain time John suggested that the claims of the barons should be referred for arbitration they realised that it would be wise to get all the support they could, and so they joined with themselves the clergy and the ordinary people, and thus in the charter which they presented they demanded rights and liberties for the whole nation.

John saw that the game was up, and therefore agreed to meet the barons. It is one of the most famous and dramatic meetings in all history.

The king was staying at Windsor, and the barons with their supporters had gathered at Staines, so a place was selected for the meeting about half-way between. It still exists, a broad meadow by the side of the River Thames about three miles from Windsor, and its name of Runnymede, meaning " the meadow of counsel or speech," stands out with dazzling brilliance on the page of English history.

Early on the morning of June 15th in the year 1215, twenty-five of the barons went to the meadow, taking with them a list of the grievances that they were now determined should be set right. The king arrived from Windsor, and then discussions began. No doubt these were angry, and the king again sought delay. But his powerful opponents this time were not to be put off.

Throughout the day the arguments went on, and before nightfall John, now thoroughly overawed by the industrious clerk would be able to perform the task in a few hours.

During the next three days the king and the barons continued to meet at Runnymede and adjusted various details. During this time several copies of the document, which came to be known as the Great Charter, were prepared, and on June 10th everything was settled and the twenty-five barons were appointed as executors to see that the king did not break his word. All parties took an oath to abide by the terms of the Charter, and copies were sent to various places to be read to the people. In addition to the one, already referred to, in the British Museum, there is a sealed copy at Lincoln Cathedral and another one at Salisbury Cathedral, while a fourth copy is at the British Museum, on which no trace of the Seal is left.

A King With a Heart of Stone

Although John agreed to the Charter only under compulsion, there were those who really believed that he had sealed it willingly. An old historian tells us that the barons exulted in the belief that " God had compassionately touched the king's heart of stone and given him one of flesh," and, further, that they believed that " he was happily inclined to all gentleness and peace." The same historian, however, tells us that some of the people round the king

said, with laughter and jeers, as he sealed the Charter, that he was no longer a king but a slave and scum of the people. At this he fell into a rage, gnashed his teeth, scowled with his eyes, and seizing sticks and limbs of trees, began to gnaw them.

Directly the meeting at Runnymede broke up John was furious that he had sealed the famous document. We are told that he was "constantly raging, biting and tearing his nails, and muttering, and gnashing his teeth, cursing his father and mother, raving and saying that he had twenty-five kings set over him."

He certainly had no intention of keeping his promise, and at once increased his paid retainers and asked Philip of France and the Pope for help against the barons. The Pope took John's side, excommunicated the barons, and laid London under an interdict. But by this time the people had got used to this sort of thing, and treated the Pope's threats with contempt. Even the priests would not publish them.

John went about the West of England, pillaging and destroying till he had lost nearly all his remaining friends. Finally, he returned to the Eastern counties, lost all his baggage while crossing the River Welland where it runs into the Wash, and being much upset by this disaster and by over-eating and drinking, he fell ill and died little more than a year after sealing the Charter.

Rights given to All

What was the Great Charter which John sealed, and which has meant so much to Englishmen in the seven centuries that have followed?

Well, it was won by a combination between all classes of freemen and gave rights to all of them. The Church was to be free and its privileges respected, the feudal rights of the nobles were to be observed, the privileges of the towns were guaranteed, merchants were to be able to travel freely and carry on their business without interference, and justice was to be meted out to all citizens.

One article of the Charter says, "To none will we sell, to none will we refuse, to none will we delay Right and Justice." Another article says, "No freeman shall be arrested or imprisoned or dispossessed of his tenement or outlawed or exiled or in any way proceeded against unless by the legal judgment of his peers or by the law of the land." Peers, of course, means equals, and this was the beginning of trial by jury. Still another article declares, "No freeman, merchant or villein (that is husbandman) shall be excessively fined for a small offence; the first shall not be deprived of his means of livelihood, the second of his merchandise, the third of his implements of husbandry."

Much of the Magna Carta holds good to-day, and it is interesting to see how it works. One example will serve. Some years ago a poor woman in London owed money to a man, and as she could not pay he went to law and got an order from the judge enabling him to take from the woman enough property to settle his debt.

King John gives his consent to Magna Carta at Runnymede

The woman was a seamstress and earned her living by her sewing machine. When the creditor sent bailiffs to seize enough property to pay the debt these men took the sewing machine, whereupon the woman went to the magistrate and told him what had happened. The magistrate declared at once that the law had been broken, and he ordered the creditor to give back the sewing machine and pay the woman a sum of money for having broken the law. The bailiffs acting for the creditor had infringed Magna Carta, and the poor woman, claiming her rights under the Great Charter, was supported by the magistrate and obtained damages.

We can see that it is a wise rule that men and women should be allowed in all circumstances to keep the tools by which they earn their living It is one of the articles of Magna Carta, already quoted, which enforces this.

It is interesting to know that this famous document was not at first called Magna Carta, or the Great Charter. It was spoken of as Carta Libertatum, or the Charter of Liberties, and it was also named Carta Baronum, or the Charter of the Barons Not until the succeeding reign of Henry III was it called the Great Charter, and then, strangely enough, the adjective "Great" was given to it, not because of its merits and importance, but because of the size of the parchment on which it was written. It was called Magna Carta because it was larger than a Parva Carta, or Little Charter, granted by Henry in 1237.

Indeed, after the Great Charter had established itself as part of the law of the land, it was almost forgotten. Only when the Stuart kings tried once more to filch away the liberties of the people was the Great Charter again invoked.

A Corner-stone of Liberty

Its title of Great was now understood in a far higher sense than in Henry III's reign It came to be realised how much the nation owed to the Charter of the Barons, and it grew in importance in the popular imagination. In fact, one great constitutional historian, Dr. William McKechnie, says: "In many a time of national crisis the Magna Carta has been appealed to as a fundamental law too sacred to be altered—as a talisman containing some magic spell capable of averting national calamity."

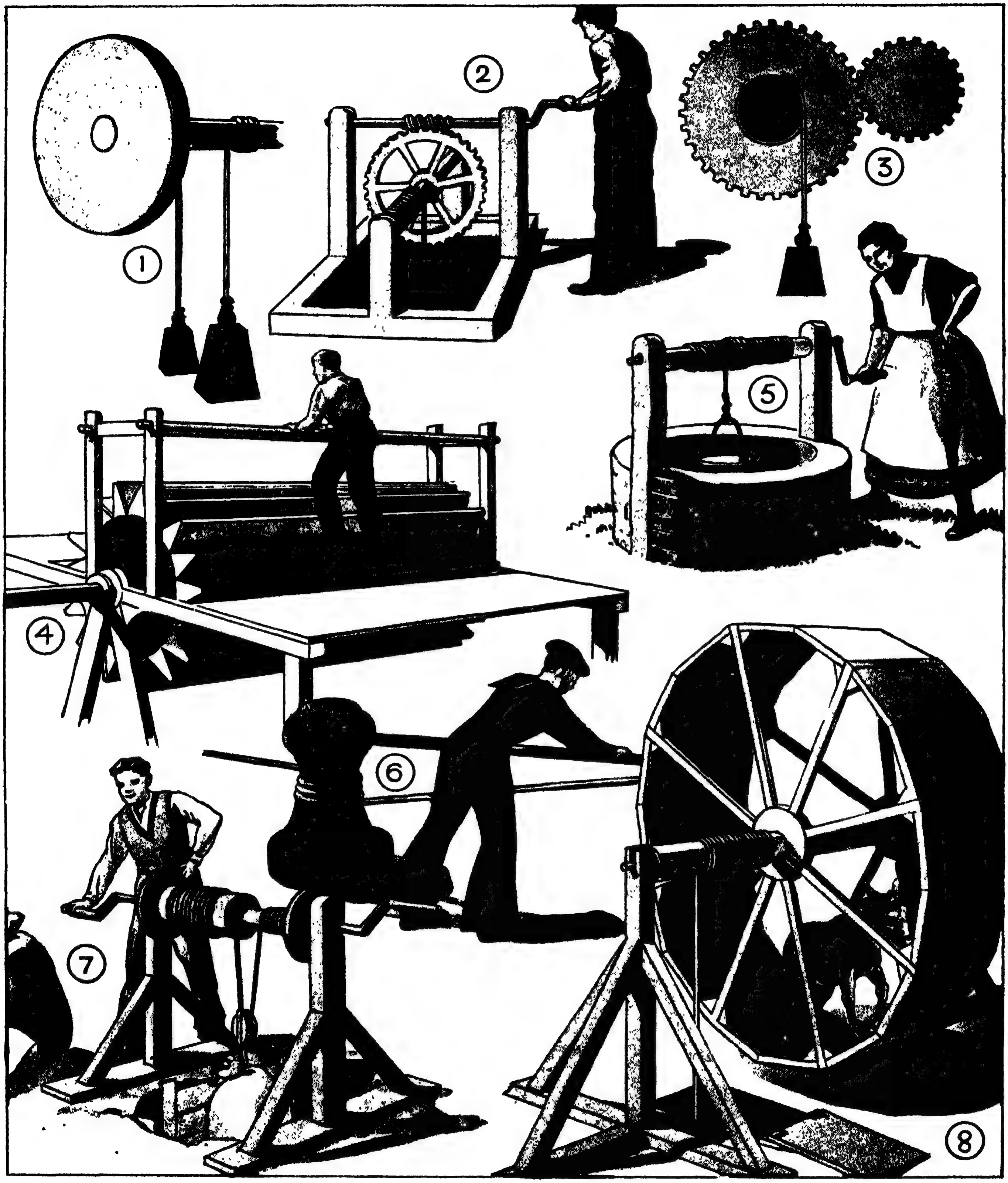
We do not want to have any false notions of this kind about Magna Carta, but we should realise that its value depends on the nature of its provisions, and that these are just and moderate, set forth in clear, straightforward language, and that they have commended themselves to all right-thinking Englishmen in the ages that have followed

Much of Magna Carta remains as part of the law of England even now, and it is still the safeguard of our liberty. Mr. Rudyard Kipling puts the matter very tellingly in his poem "The Reeds at Runnymede." He urges us to remember the great event of 1215:

> Forget not after all these years
> The Charter signed at Runnymede.
> And still when Mob or Monarch lays
> Too rude a hand on English ways,
> The whisper wakes, the shudder plays
> Across the reeds at Runnymede.

The great document will never be forgotten, for it is ever in the minds and memories of liberty-loving Englishmen. Magna Carta is the glorious heritage of every English boy and girl to-day.

WAYS IN WHICH WE USE THE WHEEL AND AXLE



The wheel and axle is a very useful device of the lever type, by which a small power exerted through a great space can produce a great power acting through a small space. It consists, as its name implies, of a wheel attached to an axle, and is really a continuous lever. Its principle is shown in the first picture, where a small weight acting on the large circumference of the wheel will raise a large weight on the small circumference of the axle. Various examples of it are given on this page. 1. The principle of the wheel and axle. 2. Worm gear windlass. 3. Wheel and axle, with toothed wheel worked by another toothed wheel. 4. Treadmill. 5. Windlass of well. 6. Capstan of ship. 7. Differential wheel and axle, also called a Chinese windlass. 8. Donkey wheel for raising water

MARVELS OF MACHINERY

THE VALUE OF THE WHEEL AND AXLE

The most complicated machinery is based on simple principles, and it is interesting to see these principles in their elementary form and to realise how much they come into everyday use. One of these principles is known as the Wheel and Axle, and in these pages we read about its great use to mankind and see many examples of how it is brought into daily service

The value of the lever in helping man to do his work in comfort and ease can be recognised even by those who know practically nothing of mechanics. In some form or other we all use the lever every day and every hour.

Even the newly born infant, when it moves its arms, is making use of the principle of the lever, and not only does elaborate machinery embody the principle, but even the simplest devices and operations. Scissors, tongs, pliers, pincers, nutcrackers, keys, and scales, as we see on page 4, are all levers, and even the children, when they play see-saw and push a wheelbarrow, or dig in their little gardens, are using the principle of the lever.

An ingenious development of the lever is known as the wheel and axle, and it comes into many operations of daily life. It is really a continuous lever, and bears the same relation to the ordinary simple lever such as the crowbar or pump handle, that a turbine engine bears to an ordinary reciprocating or to-and-fro engine with cranks.

A Working Advantage

The wheel and axle consists of two cylinders with the same axis, but with one cylinder larger than the other. The large cylinder is known as the wheel, while the smaller one is called the axle. There is no definite proportion between the sizes of these. There may be a great difference with the wheel very large and the axle very small, or on the other hand there may be not much difference in the diameters of the two.

The value of the wheel and axle, however, as a machine giving a great working advantage to the man who uses it, is in there being a considerable difference in the diameters of the wheel and axle; the larger the wheel in proportion to the axle the greater being the mechanical advantage. Let us see the principle of this very useful mechanical device.

In its simplest form we see the wheel and axle in the windlass by which water is drawn up from a well, or a heavy pail of material from a pit or mine. In this case a handle is substituted for the wheel, but the principle is, of course, the same. In the domestic mangle the wheel is retained and the handle attached to the wheel.

In the windlass the rope by which the pail is drawn up is wound round the circumference of the axle, and by means of a handle (corresponding to a wheel) attached to the axle, is turned round and round. At each turn of the wheel the axle also makes one turn; but, of course, any point on the circumference of the wheel passes through a much greater distance than a point on the circumference of the axle. The result of this is the same as when one arm of a bar lever is much longer than the other arm. The hand moving the long arm of the lever passes through a much greater distance than the weight is raised by the other arm. So in the windlass the weight or power applied to the wheel raises a much greater weight or asserts a much greater power by means of the smaller axle.

As a device, the wheel and axle gains in power in proportion as the circumference of the wheel is greater than that of the axle. Thus, supposing the circumference of the wheel to be ten times that of the axle, then a force or weight equal to one pound attached to the wheel will balance ten pounds attached to the axle.

Another adaptation of the wheel and axle is the capstan of a ship, but here the place of the actual wheel is taken by spokes. In the bicycle we see the principle of the wheel and axle in the treadles and driving wheel around which the chain turns. The first picture on the opposite page showing the wheel and axle in its simplest form helps us to understand how this device forms a lever.

The radius of the wheel is the large arm of the lever and the radius of the axle the short arm.

Law of the Lever

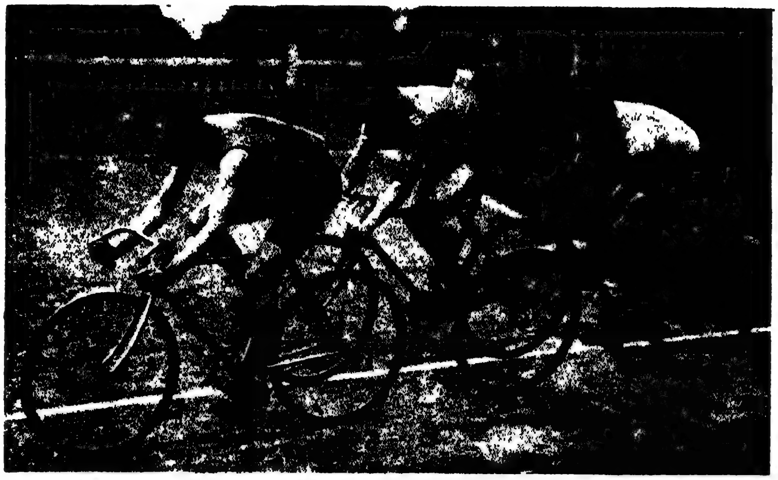
The laws relating to the wheel and axle are practically the same as those of the simple lever, the force applied to the wheel having exactly the same relation to the weight raised by the axle as the radius of the axle bears to the radius of the wheel. To put it in another way, if the radius of the axle is three inches and the radius of the wheel twelve inches, then a force equal to one pound applied to the wheel will balance a weight of four pounds on the axle. Mathematical people would say that the power multiplied by the radius of the wheel is equal to the weight raised multiplied by the radius of the axle. This may sound a little complicated, but it is really easy to understand.

Of course, in using the wheel and axle the work done is not always that of raising weight. Sometimes

The wheel and axle is used in an infinite variety of machinery, and here we see it in action in the pump that supplies air to a diver while he is under the water

we apply a small force at the wheel in order to exert a large force at the axle. The best example of this use of the valuable device is in the mangle or wringer which we see used in our homes

A great deal of force is required to wring the water out of freshly washed clothes, or to smooth out the creases after they have been rough dried. Such a force applied directly would be beyond the powers of the maid or washerwoman, but by using the mangle in which the rollers are the axle, and the handle the wheel, we are able to exert the necessary pressure at the rollers by means of very much less force at the handle.



The pedal of a bicycle is a familiar example of the wheel and axle

The old treadmill used in prisons, the device for using water at Carisbrooke Castle in which a donkey turns the wheel, spits for roasting that were turned by small dogs, are all examples of the use of the wheel and axle.

It is also brought into service in many forms of crane. Sometimes the power is applied by human hands and arms turning a handle or wheel, and in other cases it is applied by means of a band round the wheel worked by steam or other power. At other times the wheel may have teeth or cogs at its circumference and it may be turned by a smaller cogwheel working in conjunction with it. The device known as a Chinese windlass is another adaptation of the wheel and axle.

A still further adaptation is seen in the trains of toothed wheels which are used in raising great weights by the exertion of a very small power, as in screw-jacks, crab-winches, and so on. And still another use of the wheel and axle is in clocks and watches, where changes in velocity or power are obtained by such trains of wheel work.

No one knows who invented this very useful contrivance. It was probably discovered very early in the world's history, just as the lever was discovered. But, of course, there is much more evidence of invention in the wheel and axle than in the ordinary bar lever.

The advantage of the ordinary lever was probably discovered rather than invented, whereas the wheel and axle, even in its simplest form, is a distinct invention. It does not exist ready-made in nature as does the simple lever.

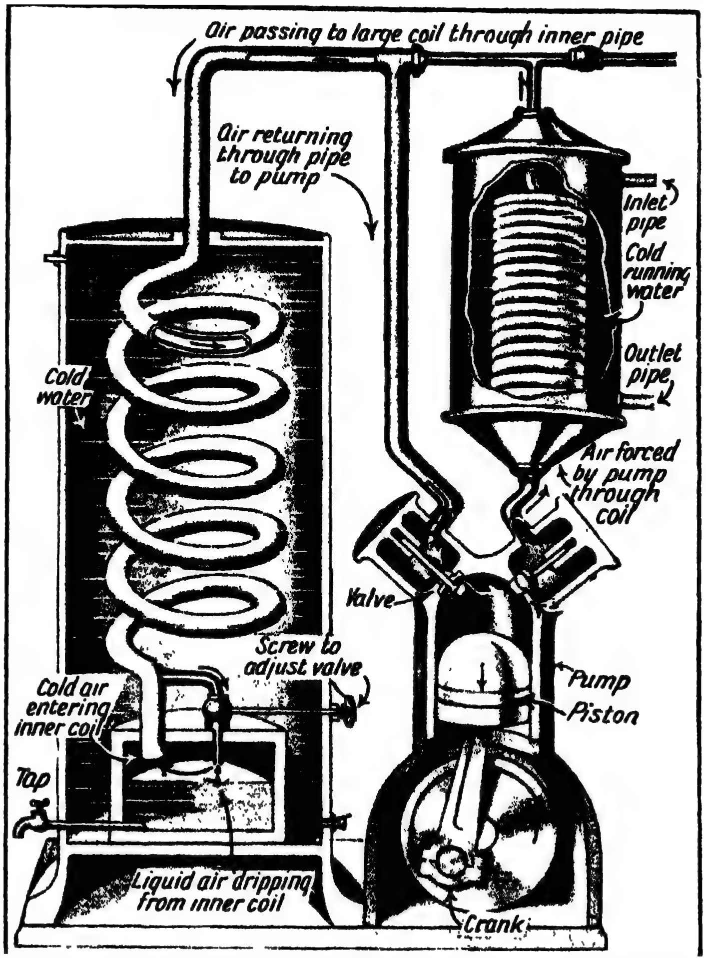
We honour men like Thomas Alva Edison and James Watt and Sir Richard Arkwright for their very valuable inventions in machinery, but we rarely give a thought to those men who invented the simpler devices in far away ages, which have enabled the inventors of later days to produce such wonderful machines.

We think of the men of to-day with their ingenious and complicated contrivances, like printing machines and motor-cars, as being much cleverer than those men of old, but of course this is not the case. The unknown men of the twilight of history, who first thought of ideas like the wheel and axle, were really quite as clever, if not more so, than the later inventors of more complicated machines.

They had no earlier inventions to serve by way of inspiration, whereas there is no doubt that in these days invention breeds invention, and one clever device will give an idea to another inventor for a machine to do quite different work. Let us honour the known inventors of to-day, and not forget the unknown men of the past.

The wheel and axle is found in old machinery as well as in new, and here is a rather crude example of it in an old cider mill in Gloucestershire, which has been in use for two centuries

HOW AIR IS TURNED INTO A LIQUID



The machine that changes the air we breathe into a liquid like water

The air we breathe is quite invisible to us, and except when the wind is blowing hard we rarely notice it. Yet it can be changed from a gas into a liquid. The picture on this page shows how this is done.

The principle depends upon the fact that when a gas is compressed its temperature always rises, and when it expands its temperature falls. During expansion it is really working and so giving off energy in the form of heat.

Air Under Pressure

A pump worked by some form of power, such as steam or electricity, is connected with a coil of pipe surrounded by cold running water shown on the right. The pump draws in air through a valve from the pipe, shown in the middle of the picture. It then forces this at a pressure of about 200 atmospheres through another valve, seen on the right, and into the coil in the top right-hand part of the picture.

Here the air is cooled to the temperature of the cold water running outside the coil. It passes up into a small pipe which runs inside a larger pipe round which cold water is also circulating. This is shown on the left of the picture.

At the end of the small pipe the air passes through a valve and expands, entering a vessel or chamber. Then it enters the larger pipe of the coil and ascends, passing outside the small pipe and down into the pump once more. Again it is pumped through the coil on the right and the whole process goes on again and again without cessation.

When the air expands in the vessel at the bottom left-hand corner of the picture, it gets cooler because it gives up heat, and so as it ascends through the outer coil it is able to cool the air in the inner coil. At last the air in the inner coil becomes so cold that it reaches a temperature of about −182 degrees Centigrade, and condenses into a liquid. It is then drawn off by a tube and tap.

To make a cubic inch of liquid air, about half a cubic foot of ordinary air is required. As the air is liquefied, fresh air passes through a pipe to the pump from outside. This pipe is shown in the top right-hand corner of the drawing.

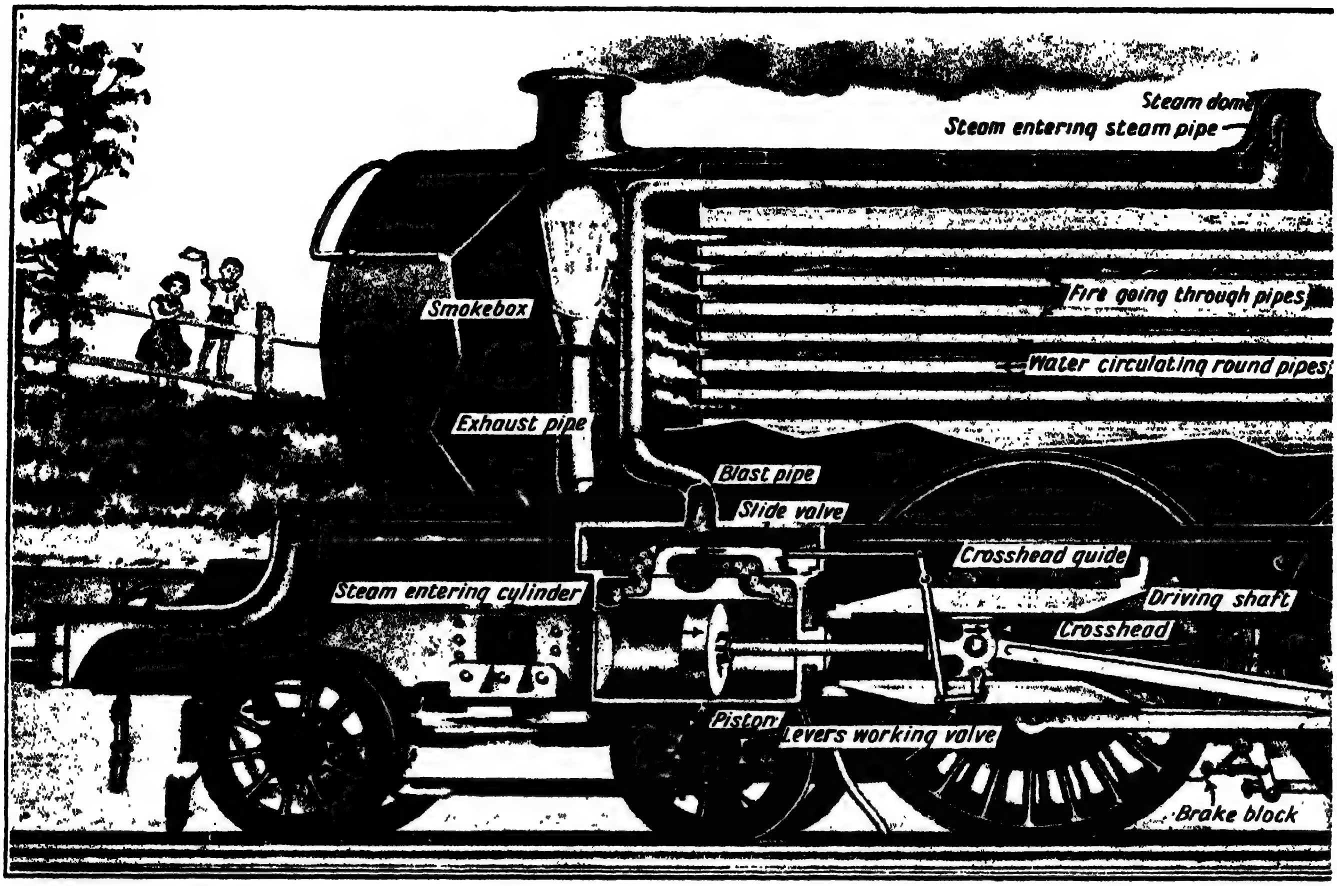
Keeping Air Liquid

When air was first liquefied the problem was to keep it and transport it in that condition. Obviously if it came in contact with the ordinary temperatures of the air we breathe, it would at once change back into a gas. Sir James Dewar, the great British physicist, solved the difficulty by placing it in a kind of thermos flask. This was a vessel with double walls and the space between the walls consisted of a vacuum. This served as a perfect insulation, and such vessels are now used for the purpose of keeping air liquid.

HOW THE QUARRYMAN SPLITS THE ROCKS WITH WATER

The quarryman in some parts uses water to split the massive rocks. He first makes a crack or groove with a pickaxe, as shown on the left, and then inserts a number of wedges. When the wooden wedges are in place the quarryman pours water over them, as in the centre picture, till they are saturated. The result is that they swell, and as the crack is not big enough to allow for this, they gradually make it wider. At last the small crack made with the pickaxe has been enlarged so much by the gradually swelling wedges that a block of stone is parted completely from the rocky bed or mountain side, as shown on the right

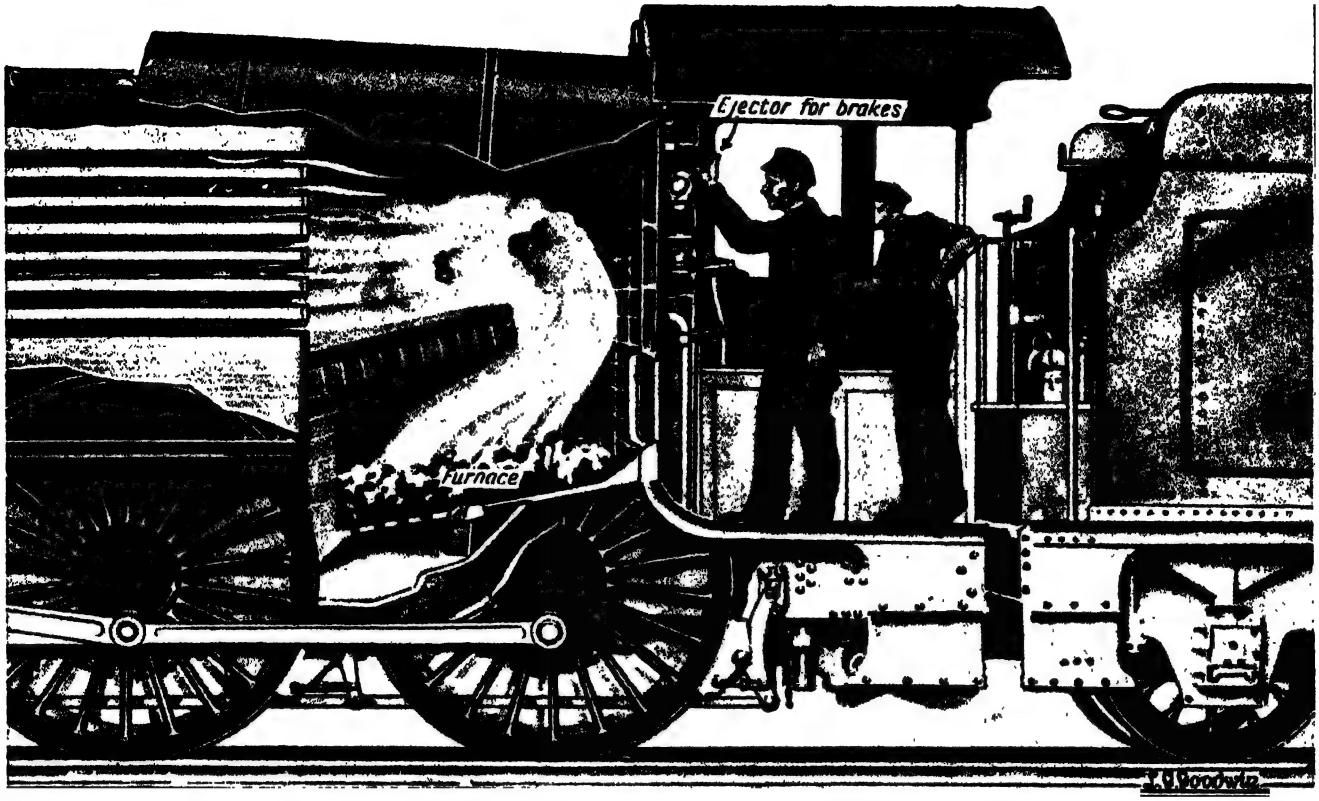
TWO TYPES OF MODERN LOCOMOTIVE



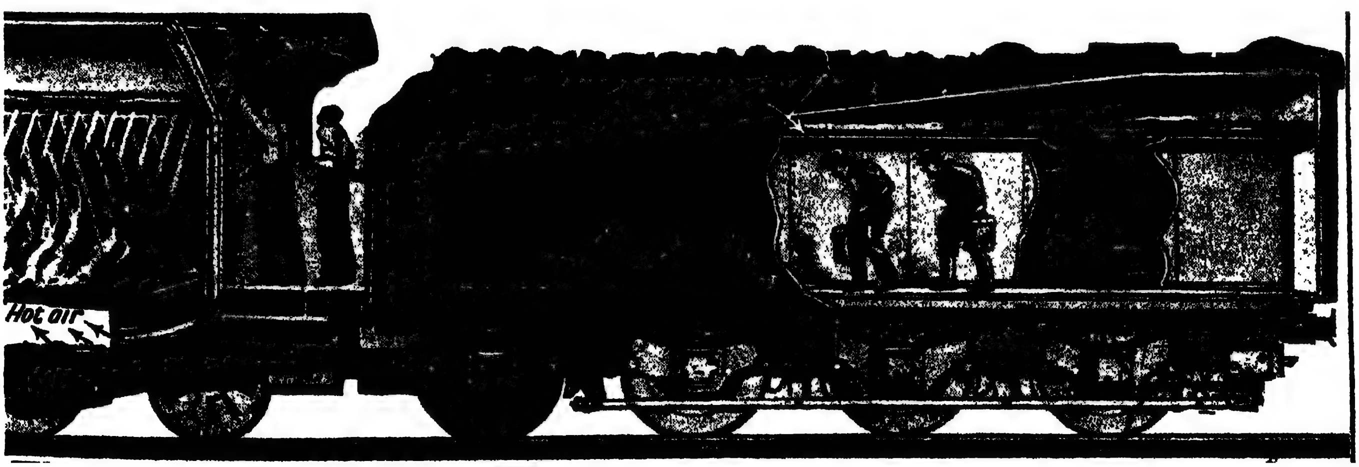
A modern locomotive is a triumph of engineering skill, although it is still built more or less on the principle laid down by George Stephenson in his little Rocket. This picture shows a locomotive of the Castle class on the Western Region of British Railways. The burning coal in the furnace sends flame and hot gases through pipes round which the water circulates. This water is heated and turned into steam, which rises to a dome and passes through a steam pipe into the front end of the cylinder. Here it forces back the piston, which by means of a piston-rod and crank, or driving shaft, turns the engine's driving wheels, which are linked together. As the wheels rotate

This engine on the Eastern Region of British Railways is different from the one above. Here the water circulates in tubes and the flames and hot gases of the furnace pass round them, turning the water into steam, which rises and goes into the main steam-drum, A, and thence into four other steam-drums, two on either side of the engine. Two of these on the side of the engine nearest to us are marked B and C in the drawing. From the drums the steam passes through a super-heater, where it is dried, and the temperature still further

AND HOW THEY HAUL THE TRAIN



they work a series of levers, which move a slide valve so that steam can now enter the back end of the cylinder and drive the piston forward. As the valve goes to and fro, steam is let in alternately first at one end and then at the other end of the cylinder, so that the piston moves backwards and forwards at a rapid rate. The steam, after it is used, passes through a blast pipe situated near the steam pipe, and escapes through an exhaust pipe into the smokebox, and thence through the funnel into the air. The rushing of the waste steam from the blast pipe includes a powerful draught and makes the furnace burn more fiercely. There are hand and power-operated brakes



raised. It then goes to the cylinders and drives the pistons, which turn the wheels as in the type of engine shown in the top drawing. In order to make the furnace burn more fiercely a stream of hot air rushes up from under the grate. Cold air enters the front of the engine and passes over the casing of the boiler, where it is warmed before entering the furnace. A relief driver and fireman are carried on the train, and half-way on the journey they go to the cab of the locomotive through a narrow corridor at the side of the tender

A PEAK VANQUISHED BY ENGLISHMEN

The Matterhorn of Switzerland, though not the tallest, is one of the most imposing peaks in the whole of the Alps. From the Swiss side it stands up majestically like an isolated obelisk, but really it is only the end of a ridge which can be seen from the other side. It is 14,780 feet high and is made of hard crystalline rocks known as schists. The strata or layers of which it is composed were at one time pushed up by some subterranean convulsion or pressure and thrust over. Then, as the ages went by, the softer rocks round about were worn away by the weather, and the hard ridge with its peak was left standing up between two valleys. It is the hard rock of which it is composed which gives the jagged appearance to the Matterhorn. This peak remained unconquered till 1865, when a party of Englishmen with Swiss guides reached the summit. Since then it has been often climbed, but the ascent is now much easier, for the rocks at difficult places have been blasted away, and a rope to help the climber has been fixed in position

THE CONQUEST OF AN ALPINE PEAK

No matter how formidable Nature may show herself, man is always determined to conquer her. There was a time in his history when he feared the mountains, but now peak after peak is attacked by climbers and one after another is conquered. One day Everest itself, the highest mountain in the world, will be scaled. In these pages we read the thrilling story of how the Matterhorn, one of the great peaks of the Alps, was conquered by an English party of climbers who were the first to reach the top

In ancient times the great masses of the Alps were regarded with terror. They were thought to be the abode of gods, many of whom were far from friendly to the human race, and the valleys were inhabited in the popular imagination by all kinds of supernatural beings. The dark shadows cast by the peaks, the roaring of the mountain torrents, the crashing of the avalanche, all struck terror into the hearts of those who lived or travelled in such a region.

Man feared the mountains largely because he did not understand them. But as the centuries passed the mountains became more and more familiar, their character and formation were understood, and so far from being a place of terror the Alpine region is now spoken of as the Playground of Europe.

Bids for Victory

Every year thousands of people make their way to Switzerland to take part in winter sports or to climb the peaks in summer. No mountain is too high or too steep or too forbidding to scare the mountaineer, and one after another the peaks are conquered and mountain-climbers are now as "thick as autumnal leaves that strow the brooks in Vallombrosa."

Having conquered the Alps, the highest peak of which is rather less than 16,000 feet, men are now attacking the loftiest mountains in the world, Mount Everest and its companions, which are nearly twice the height of Mont Blanc.

The conquest of the mountains has not been easy. Many a gallant mountaineer has lost his life in the contest, but sooner or later the thrill of victory has come, as it will one day, no doubt, to those who try to vanquish Mount Everest. Victory rarely comes at the first or second attempt, and on many of the Alpine peaks assault after assault has been directed before the topmost pinnacle was reached.

One of the greatest triumphs of the mountaineer was the conquest of the Matterhorn, a forbidding peak of 14,705 feet, with its slopes facing Switzerland on one side and Italy on the other.

It is to an Englishman, Mr. Edward Whymper, that the honour is due of having first climbed to the top of the Matterhorn. It had always been regarded as absolutely unclimbable, but Mr. Whymper made up his mind in 1861 that he would attempt to conquer the difficult peak from the Italian side. Of the many guides who lived round about the mountain only one named Carrel thought this was possible One guide, when asked to accompany him, replied: "Why don't you try to go up a mountain which *can* be ascended?"

Again and again did Edward Whymper try to climb the Matterhorn, sometimes with guides and on one occasion quite alone. On that occasion he reached a greater height than any yet attained, but coming down he fell and was whirled over and over in a series of bounds, each longer than the last, over ice and rocks.

An English party reaching the peak of the Matterhorn for the first time. The picture shows how climbers are roped together and how, where the rope becomes slack, it is caught up in the hand, so that if a climber slips he does not fall far

He struck his head four or five times, and the final bound sent him spinning in a leap of fifty or sixty feet, from one side of a gully to the other He bounced over the rocks, but managed to come to a halt on the verge of a precipice, while the crash of rocks which he had started fell on the glacier below. Ten feet more and Whymper would have been hurled 800 feet on to the glacier

Joining Forces

This experience, however, did not damp his ardour He finally reached safety, and the following year made another attack on the Matterhorn, but without success.

In 1865 he made his eighth and last attempt on the Italian side, which convinced him that while it looked less steep than the Swiss side it was really more difficult. He determined, therefore, to make another attempt on the Swiss side.

When he got to Zermatt to make arrangements, he found that another expedition, consisting of a Mr. Hudson and his young friend, Mr. Hadow, had already engaged one of the guides he had decided upon. Whymper had been joined by Lord Francis Douglas and had engaged a guide named Taugwalder and his two sons. It was thought better to join forces, and so the two expeditions became one.

On July 13th, 1865, at half-past five on a brilliant and cloudless morning, the expedition started. There were eight in all—the guides Croz and Taugwalder, the two sons of Taugwalder who were taken as porters and carried provisions, Mr Whymper, Lord Francis

Douglas, and Messrs. Hudson and Hadow.

On the first day the party travelled in leisurely fashion and reached a position at a height of 11,000 feet, where they fixed a tent in a protected spot. Croz and young Peter Taugwalder were sent a little farther on to see what was above, so that preparations could be made for the following morning. When they came back they declared that there appeared no difficulties and that the party could easily reach the summit.

The next day the whole party started as soon as it was light enough to see. Young Peter Taugwalder went with the party now as a guide, while his brother returned to Zermatt from which the expedition had started.

Good progress was made. Sometimes Edward Whymper led and sometimes Mr. Hudson. One or two halts were made, and then at a height of 14,000 feet travelling became much more difficult. The slope of the mountain was much more acute, and the snow was in many places covered with a film of ice. There was a good deal of doubling back, but nevertheless steady progress was made towards the top, and then after a stride round an awkward corner it was seen that nothing but 200 feet of easy snow remained to be surmounted

Intense Excitement

Now two days before Whymper's party had started, a party of seven Italians with the guide, Carrel, had started from the Italian side, and, of course, the Englishmen were tormented with anxiety lest these might reach the top first.

"All the way up," says Mr. Whymper, "we had talked of them and many false alarms of men on the summit had been raised. The higher we rose the more intense became the excitement. What if we should be beaten at the last moment? The slope eased off, at length we could be detached, and Croz and I dashing away ran a neck-and-neck race, which ended in a dead heat.

"At 1.40 p.m. the world was at our feet, and the Matterhorn was conquered. Hurrah! Not a footstep could be seen. It was not yet certain that we had not been beaten. The summit of the Matterhorn was formed of a rudely level ridge about 350 feet long and the Italians might have been at its farther extremity.

"I hastened to the southern end, scanning the snow right and left eagerly. Hurrah again! It was untrodden Where were the men?

"I peered over the cliff, half doubting, half expectant, and saw them immediately—mere dots on the ridge at an immense distance below. Up went my arms and my hat.

"'Croz! Croz! Come here!'

"'Where are they, monsieur?'

"'There! Don't you see them—down there? Croz, we must make those fellows hear us!'

A Flag of Victory

"We yelled until we were hoarse. The Italians seemed to regard us—we could not be certain.

"'Croz, we must make them hear us! They shall hear us!'

"I seized a block of rock and hurled it down, and called upon my companion in the name of friendship to do the same. We drove our sticks in and prized away the crags, and soon a torrent of stones poured down the cliffs. There was no mistake about it this time. The Italians turned and fled."

The picture on the left shows the proper way to go up or down a mountain, and the picture on the right shows the wrong way to do this

The other members of the English party reached the top, a tent pole was stuck in the snow for a flag mast, and Croz, taking off his blouse, fixed it as a flag to the stick. It was seen from all round the base of the Matterhorn from Zermatt and from Breuil on the Italian side. There the watchers cried exultingly, "Victory is ours!" And they raised cheers for Carrel and for Italy, for they naturally supposed that the party which had started a few days earlier from Breuil had reached the summit. It must have been a bitter disappointment on the following day when they learnt the real truth.

Beginning the Descent

The descent now had to be made, and it was arranged that Croz should go first, Hadow (who was inexperienced) second, Hudson third, Lord Francis Douglas next, and old Peter after him. These were all fastened together with a rope, and then Whymper tied himself to young Peter Taugwalder and joined the others.

The descent was begun with great care, only one man moving at a time, and when he was firmly planted the next advanced, and so on. At first Whymper and young Taugwalder were detached from the others, but later they tied on to old Peter. And now a terrible thing happened. Mr. Whymper must tell the story himself:

"A few minutes later a sharp-eyed lad ran into the Monte Rosa Hotel, to Seiler, saying that he had seen an avalanche fall from the summit of the Matterhorn on to the Matterhorngletscher. The boy was reproved for telling idle stories. He was right, nevertheless, and this was what he saw.

"Michel Groz had laid aside his axe and, in order to give Mr. Hadow greater security, was absolutely taking hold of his legs and putting his feet, one by one, into their proper positions. So far as I know, no one was actually descending. I cannot speak with certainty, because the two leading men were partially hidden from my sight by an intervening mass of rock, but it is my belief, from the movements of their shoulders, that Croz, having done as I have said, was in the act of turning round to go down a step or two himself. At this moment Mr. Hadow slipped, fell against him, and knocked him over.

The Rope Breaks

"I heard one startled exclamation from Croz, then saw him and Mr. Hadow flying downwards; in another moment Hudson was dragged from his steps, and Lord Francis Douglas immediately after him. All this was the work of a moment.

"Immediately we heard Croz's exclamation, old Peter and I planted ourselves as firmly as the rocks would permit; the rope was taut between us, and the jerk came on us both as on one man. We held; but the rope broke midway between Taugwalder and Lord Francis Douglas. For a few seconds we saw our unfortunate companions sliding downwards on their backs and spreading out their hands, endeavouring to save themselves. They passed from our sight uninjured, disappeared one by one, and fell from precipice to precipice on to the Matterhorngletscher below, a distance of nearly 4,000 feet in height. From the moment the rope broke it was impossible to help them.

"So perished our comrades. For the space of half an hour we remained on the spot, without moving a single step. The two men, paralysed by terror, cried like infants, and trembled in such a manner as to threaten us with the fate of the others. Old Peter rent the air with exclamations of 'Chamounix! Oh, what will Chamounix say?' He meant, Who would believe that Croz could fall? The young man did nothing but scream or sob 'We are lost! We are lost!'

A Father's Bitter Cry

"Fixed between the two, I could neither move up nor down. I begged young Peter to descend, but he dared not. Unless he did, we could not advance. Old Peter became alive to the danger and swelled the cry, 'We are lost! We are lost!' The father's fear was natural—he trembled for his son; the young man's fear was cowardly—he thought of self alone.

"At last old Peter summoned up courage and changed his position to a rock to which he could fix the rope; the young man then descended, and we all stood together. Immediately we did so I asked for the rope which had given way, and found, to my surprise—indeed, to my horror—that it was the weakest of the three ropes. It was not brought, and should not have been employed, for the purpose for which it was used. It was old rope and, compared with the others, was feeble. It was intended as a reserve, in case we had to leave much rope behind, attached to rocks. I saw at once that a serious question was involved, and made him give me the end. It had broken in mid-air, and it did not appear to have sustained previous injury.

Two Hours of Deadly Peril

"For more than two hours afterwards I thought almost every moment that the next would be my last; for the Taugwalders, utterly unnerved, were not only incapable of giving assistance, but were in such a state that a slip might have been expected from them at any moment. After a time we were able to do that which should have been done at first, and fixed rope to firm rocks, in addition to being tied together. These ropes were cut from time to time, and were left behind. Even with their assurance the men were afraid to proceed, and several times old Peter turned with ashy face and faltering limbs and said, with terrible emphasis, 'I cannot!'

A Tragic Victory

"About 6 p.m. we arrived at the snow upon the ridge descending towards Zermatt, and all peril was over. We frequently looked, but in vain, for traces of our unfortunate companions; we bent over the ridge and cried to them, but no sound returned."

It was a terrible tragedy on the very day of victory, and reminds us almost of the day of Trafalgar, when, at the moment of victory, the great commander Nelson fell mortally wounded.

But, despite such events, the spirit of man always rises above circumstances, and the conquest of the Matterhorn has only inspired other brave mountaineers to conquer still more difficult peaks including Everest, the mightiest of all.

A STRANGE APPEARANCE SEEN ON MOUNTAIN TOPS

All kinds of curious natural phenomena are to be seen in mountainous regions, and one of the strangest and most striking of these is known as the Ulloa Circle. It is so called because it was first recorded by the Spanish traveller and statesman, Antonio di Ulloa.

He was on the Pambamarca Mountain in South America with six fellow travellers at daybreak one morning. The mountain was almost entirely covered with thick clouds, but when the Sun rose it dissipated these, leaving only a few light vapours here and there.

Suddenly in the direction opposite to that in which the Sun was rising Ulloa saw, at a distance of about seventy feet from where he was standing, his own image reflected in the air almost as distinctly as if it were in a mirror. The image was in the centre of three groups of circles showing some of the colours of the rainbow, and then at a greater distance from the centre was a fourth circle of only one colour.

All the circles appeared perpendicular to the horizon, and as Ulloa moved so his image moved and the circles with it. But perhaps the strangest point of all was that each of the seven men grouped on the mountain saw a similar phenomenon but with the image of himself in the centre of the circles.

The phenomenon was undoubtedly of the same nature as the rainbow.

A strange apparition that is sometimes seen on mountain tops and in the Polar regions

THE WET AND DRY SIDES OF A MOUNTAIN

This picture shows what happens to a wind laden with moisture when it reaches a high mountain. It blows up the mountain, and as it becomes colder its moisture is condensed, first into clouds, then into rain, and finally into snow. At the top of the mountain it is dry

When a warm wind passes over the sea it takes up moisture and arrives at the land well laden with water vapour. It retains this vapour so long as it remains warm, but if it meets a cold wind or is driven up where the temperature is lower the wind gives up its moisture, which condenses in small globules on particles of dust in the air. If now the wind reaches a mountain it passes up the mountain-side, and as it gets into colder regions clouds are formed. Higher up larger drops of moisture form and, being too heavy for suspension in the air, they fall as rain. The wind continues travelling up the mountain, carrying some of its moisture with it, and when it reaches the very cold heights the moisture falls as snow.

If the mountain is high, when the wind reaches the top it has given up all its moisture, and as it passes over to the other side it is a dry wind. This is what happens on the Andes of South America, the warm, moist winds from the Pacific passing up the mountains and giving up their water vapour as they travel into the colder regions. The same thing is true of the Rocky Mountains farther north. For some distance east of these mountains the rainfall is deficient owing to the dry winds from their tops.

THE WRINKLING OF THE EARTH'S CRUST

As the Earth gets older its face wrinkles more and more, just as an apple wrinkles when it becomes dry and shrinks, as shown on the right, and as the human skin wrinkles when a person becomes aged, as seen by the hand on the left. Men of science are not agreed as to the cause of the Earth's wrinkling. To some extent it is probably due to the shrinkage of the Earth owing to loss of interior heat, but this would not account for the whole of the wrinkling. When the crust was plastic the rotation of the globe caused it to flatten at the Poles, and this would cause the crust to become somewhat wrinkled and distorted. It was probably in some such way as this that the great mountain chains were formed. They, with the valleys and rifts, are the wrinkles which, if the Earth could be viewed from a great distance so as to come within the compass of the eye, as shown in the middle picture, would give it somewhat the appearance of a wrinkled apple. Of course, compared with the Earth's size, its mountains are far less pronounced than the wrinkles on the hand and apple

STRANGE NIGHTMARES OF THE SEA

There are many kinds of weird creatures living in the sea, but there would probably be few persons who would dispute the statement that the most hideous of these are found in the family to which belong the octopus, the cuttle-fish and the squid. Taken together they are known by the rather long name of Cephalopods, which is made up of two Greek words, meaning "head" and "foot." Here we read all about them

The octopus, cuttle-fish and squid are called Cephalopods, a name which means "head-footed" creatures, and they are so called because the organs which correspond with the foot of other molluscs, such as the snail, are attached to the head, forming a circle round the mouth.

Some have the foot divided into eight parts and are therefore called Octopods or "eight-feet." Some, in addition to the eight feet or arms, have two longer tentacles, making ten in all, and these are called Decapods or "ten-feet." They are all relations of the slugs and snails of our gardens, and also of the beautiful paper-nautilus.

These arms or feet, whichever we like to call them, are studded with powerful suckers, with which the creatures are able to seize their prey, and it is the way in which the larger members of the family use these terrible tentacles that has given them such a bad reputation.

Of course they vary in size from a couple of inches in length to dimensions which make them real giants of the deep. Mr. Frank Bullen tells us that the limit of size is unknown, but that specimens have been seen as big as an adult sperm whale. These huge cuttle-fish are Decapods, and have a cylindrical body with a tapering tail, something like a vane.

Backward Progress

A creature of this form with ten long arms in front of it could obviously not move forward very well, for its arms would spread out like the ribs of an umbrella and impede its progress. It therefore has in its head an opening from which it can eject water with considerable force, and when it suspects danger it does this, the ejected water coming out with such violence that the creature is thrown backward, its ten arms forming a compact bundle and being thrown with it. At the same time it stains the water with a great cloud of sepia, just as an airman puts out a smoke-screen to hide his movements.

Food for the Sperm Whale

Cuttle-fish of one kind or another are found in practically all the seas of the world, even in the Antarctic. They are not used as food much by human beings, although they are not at all bad in flavour. But fish find them very attractive, and the smaller types of cuttle-fish have no protection against the sharp teeth of the fish. The very large cuttle-fish, however, which inhabit the lower depths of the sea, are probably able to defend themselves much better; but they are believed to form a very large part of the food of sperm whales. At the same time they prey on fish, lurking amid the sepia-coloured water.

The cuttle-fish are said to possess eyes larger and more powerful in proportion to their size than any other creature's. They are set one on each side of the head, and the head, resting on a column of flexible gristly material, is able to turn in every way, so that nothing can escape the cuttle-fish's vision.

Each of the sucking discs on the tentacles has a row of sharp claws round the inner edge, and when a victim is seized the suckers hold it tightly and the claws at once begin to tear it to pieces. It is not surprising that such a weird and hideous creature, which often attains enormous size, should be the subject of all sorts of fantastic stories.

The cuttle-fish was known as far back as the times of Aristotle and Pliny. Pliny the Elder says that when he was Consul in Spain one of these monsters used to come ashore at night and plunder the salt-fish warehouses. He adds that the head filled a cask of fifteen amphorae capacity, which is about the size of a sugar hogshead, and that the tentacles were thirty feet long and so thick that a man's arms could hardly meet round them at the base. The suckers were as big as five-gallon basins. Probably Pliny had really seen a giant cuttle-fish, but we are afraid that when he wrote his account he exaggerated its size and invented the story of its burglarious habits.

Fairy Tales

In the Middle Ages wonderful stories were told of cuttle-fish that seized big vessels, with tentacles that were taller than the mast, and dragged them down with all their crews. The giant cuttle-fish is a hideous and dangerous creature to meet in the sea, but such stories as these are, of course, merely fairy stories.

An octopus seizing a crab, of which it intends to make a meal

THE IMPORTANCE OF FORESTS TO MAN

Forests are of the very greatest importance to man, but in the past they have been destroyed at an alarming rate with disastrous results. Now, all civilised countries are alive to the importance of preserving the forests and constantly planting new trees to take the place of those cut down. On this page we are told some of the reasons why the forests are so valuable

MAN could not do without the forests. They supply him with timber, wood alcohol, and a number of gums and resins. It is from the wood of the forests that we get most of our paper, and a great deal of our artificial silk which looks so attractive when woven, dyed, and made up into garments.

Yet in the past man has been very wasteful of the forests, and has destroyed them wholesale. This has had a dramatic effect upon his history, for when the forests disappear not only are the supplies of timber and other useful commodities cut off, but the very climate is changed and the whole character of a country may be transformed. In some cases it is the disappearance of forests that has led to the formation of deserts.

A forest conserves the water supply. If a hillside is planted thickly with trees the force of the rain is broken by the leaves, the soil is not washed out, and instead of being carried away down the slope is held fast by the tree roots.

If, on the other hand, the hillside is bare of trees, the raindrops come down with force, wash out the soil, and carry it away down the hill. When the forest is in a colder climate where snow falls, then the snow melts much more gradually than if the ground were bare. Instead of running away as fast as it melts, it soaks slowly through the ground and forms useful springs and underground streams. Disastrous floods are due in many cases to the fact that a country has been denuded of its trees, so that the rain or melted snow is able to run away rapidly instead of gradually.

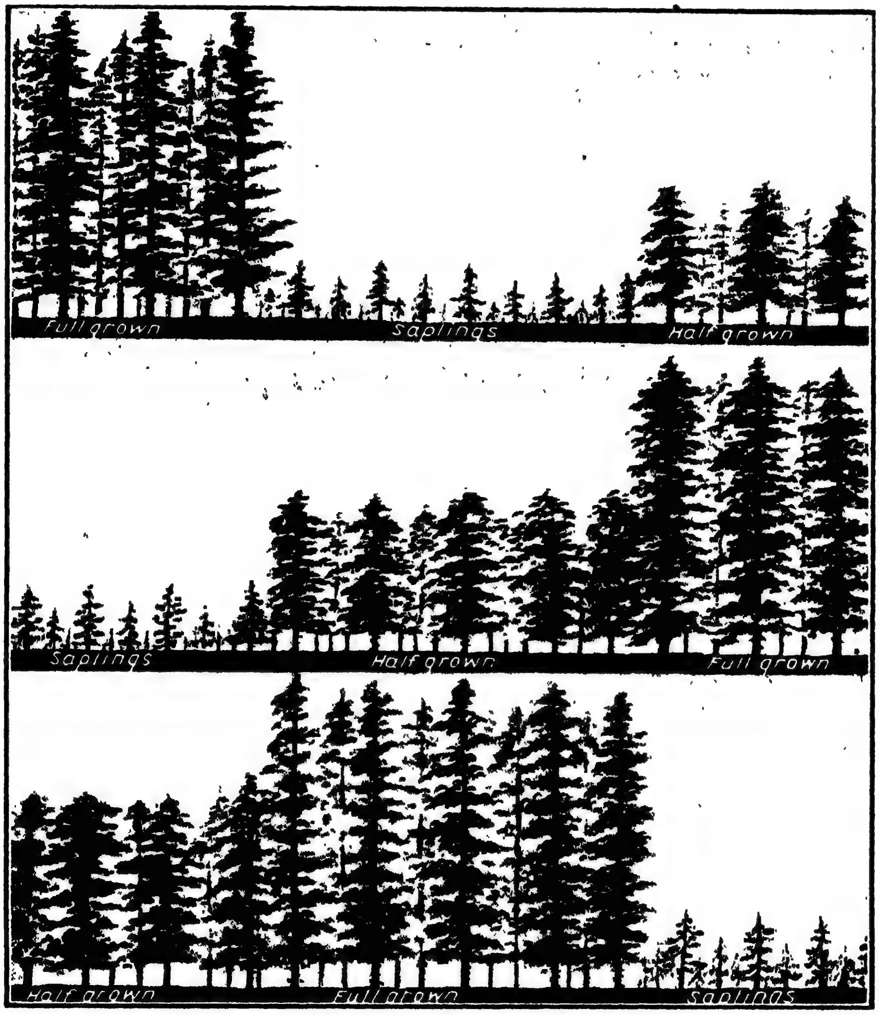
Then again the forests save the soil from being carried away into the streams and rivers and seas. The roots and the trunks and the other vegetation which the forest fosters, bind the soil and hold it. There are hilly and mountainous districts in Europe and elsewhere to-day which are bare and unprofitable, because in years gone by men have cut down the forests and the fertile soil has all been carried away so that nothing can be made to grow.

It has been estimated that every year streams and rivers carry down to the sea a quantity of soil worth over £200,000,000, and millions of money have to be spent annually in dredging harbours and river channels to remove this valuable soil that has been lost. Add to this the millions that have to be spent in irrigating dry lands which would have a greater rainfall were there forests in the district, and we get some idea of how man in the past has wasted the wealth that was within his reach.

If the old treatment of the forests had continued we should by this time have been suffering from a famine of timber. There would not have been sufficient wood for building purposes, for furniture, or for paper making. But experience has brought wisdom, and now in most countries there is a system of forest control. The tree-growing area in many lands is being increased, and as the trees are cut down for use fresh trees are planted, and it is forbidden to fell the immature trees. They must be left till they are full grown.

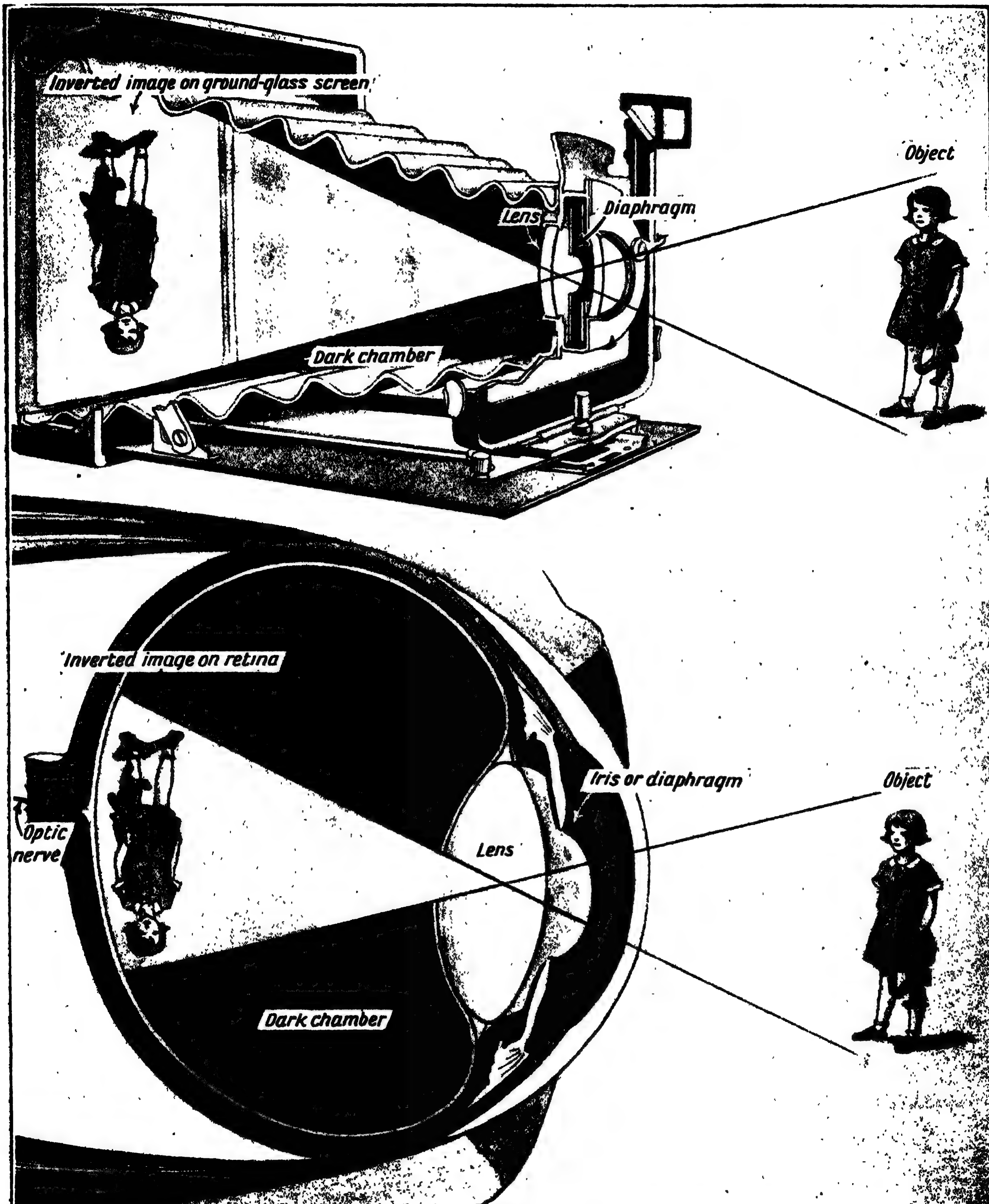
To preserve the forests it is not necessary to abstain from felling trees. The system now in force is to plant and cut at the same time and at most of the universities of civilised countries there are courses of forestry in which men learn how to grow trees wisely and well.

If they are planted too closely together the trees become stunted in growth because they cannot get sufficient nourishment from the soil or sufficient sunshine. After being planted therefore, the saplings have to be thinned out so that each may have adequate room for healthy growth. Fires, too, have to be guarded against, and insect and other pests, that war on the trees, fought.



These three pictures show how the forests are preserved so as to give a constant yield of timber for human use. The trees are cut down in zones at regular intervals, and when an area is cleared fresh trees are planted to take the place of those cut down When the full-grown trees of the first picture are cut, saplings are planted, and the saplings of the first picture are shown half-grown in the second picture. The half-grown trees of the first picture have now become full-grown, and are ready for cutting when, as shown in the third picture, saplings are planted in their place. And so there is a regular rotation, the forest being preserved in its entirety

THE EYE OF OUR BODY AND THE EYE OF A CAMERA

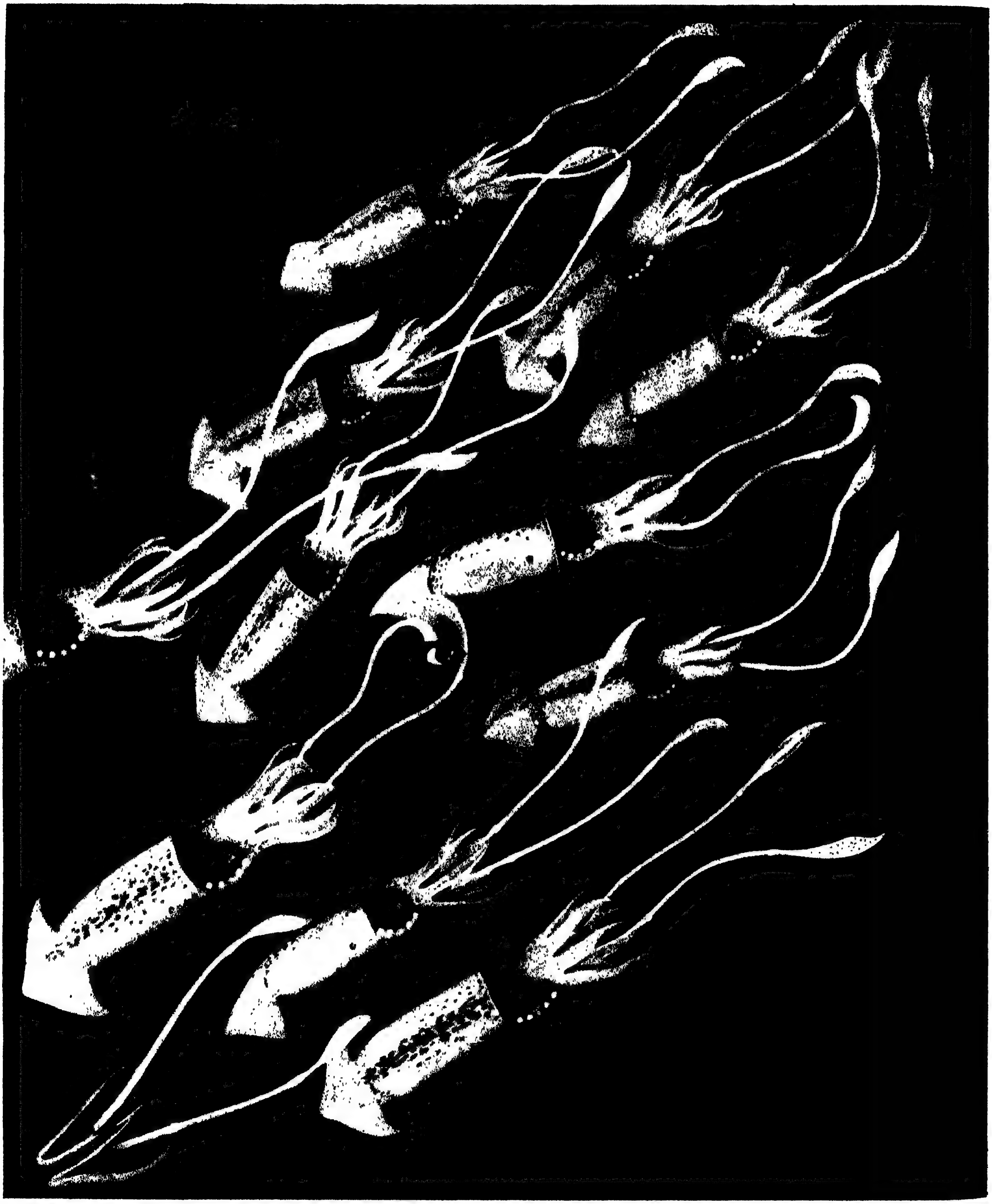


There is a remarkable resemblance between the way a picture is recorded in a camera and the way it is recorded on the retina or curtain of the eye. The camera and the eye have each a lens with a diaphragm, or kind of shutter, in front. An opening in the shutter can be made larger or smaller according to the amount of light available. In the camera this has to be worked by the operator, but in the eye it is automatic. Rays of light pass from an object through the lens as shown here, so that an inverted image appears on the screen at the back. When the inverted picture falls on the retina of the eye this stimulates the optic nerve and sends a message to the seeing part of the brain, and we get the sensation of sight. Our eyes see everything upside down, but our brains reverse the picture

HOW PLANTS GO TO SLEEP AT NIGHT-TIME

Many plants may be said to go to sleep at night and, like ourselves, their leaves and flowers take up a different position from what they do in the daytime. We lie down instead of sitting or standing, and often we curl ourselves up in bed to keep warm. The leaves of many plants also close up at night, to protect themselves from frost. In such plants as the clover the leaves droop, and it has been found that when some leaves on a plant are prevented from folding or drooping at night and the plant is exposed to frost, only the folded leaves escape, the others being killed. But as many tropical plants also fold their leaves at night the plant probably has some other purpose in taking this sleeping attitude besides protection from cold. Flowers in the same way close up their petals, or droop, to keep out the cold. On this page the flowers and leaves of a number of plants are shown by day and by night

LITTLE SQUIDS SWITCH ON THEIR LIGHTS



As mentioned in pp. 173–175 the squids or cuttle-fishes occur in all the seas of the world and vary in size from a few inches to several feet. The luminous species shown above about life size inhabits the depths of the Sea of Japan. The phosphorescence is concentrated in a number of small areas which the creature can light up separately at will. These "spotlights" both act as a lure to attract the squids' prey and also help the little copepods to keep together in a shoal, serving as recognition signals to any that have strayed from the main body

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THE MOVING HILLS OF SAND

The desert is the terror of the traveller. Many a man and even whole caravans have been swallowed up by its relentless sands. Of course, in these days of wireless and motor cars and tinned foods, it has not the same terror that it had in the old days. Yet even now the miles and miles of dry, arid territory with nothing to look upon but sand hills and sand dunes, may well appal the bravest and most adventurous. In these pages we read many facts about the desert and learn what it is really like

People who have never visited the Sahara or some similar desert, generally have a very wrong impression as to what a desert really looks like. The popular idea is that it consists of a vast level plain of sand stretching away as far as the eye can see in all directions, in very much the same way as the great level grass plains of America. But this is not at all what such a desert is like. There are hills and ridges in all directions, with valleys and undulating stretches, so that often it is not possible to see very far ahead, and the wonderful thing is that these hills and ridges and valleys move about.

If we visited a certain part of the Sahara Desert to-day and then went to it again next year, it might look entirely different then from what it does now. This may sound very mysterious, but the fact is that the moving hills and ridges are built up of sand and they are moved and drifted about by the winds that blow across the desert.

It must be remembered that the great deserts of the world, the Sahara, the Gobi, the Arabian Desert, and so on, besides those on a very much smaller scale which are found in Europe and America, have all been made by the wind. Through the centuries the winds sweeping across the sandy beaches by the sea have been blowing the sand inland and carrying it farther and farther forward till at last huge areas have been completely covered. Forests and cities and high roads, and often rivers and lakes, are sooner or later buried by the terrible sand, and in many cases where great civilisations flourished there is now nothing but an endless vista of sand.

This is particularly the case in the great Asiatic desert of Gobi. There some twenty centuries ago was a fertile country with flourishing cities, flowing rivers and great lakes It was a centre of industry and trade, with fine palaces and temples. But where are these glories now? They lie buried beneath hundreds of feet of sand carried relentlessly by the wind, and more devastating than any human army could ever be. The rivers have gone, the lakes have gone, and only at an enormous cost of men and money is the sand dug away over a small area and traces of the lost cities found and, in other parts, lost forests.

Sir Aurel Stein has unveiled some of the glories of the past in the Gobi Desert. There are paintings and statues that seem to be the work of Greek and Roman artists. There are

A sandstorm is the terror of the traveller in the desert. A hurricane of wind blows along, raising great clouds of sand and carrying these irresistibly forward. Often there are whirlwinds making whirling columns of sand like waterspouts, which rush about at terrific speed. The moving sand makes a sound like the hissing of a serpent, and travellers and their animals have to crouch down till the sand-storm has passed. Here we see a sandstorm approaching across the Egyptian desert

THE CHANGING LANDSCAPE OF A GREAT DESERT

The popular idea of a desert as a vast level stretch of sand is quite wrong. It is true that the desert is made up of vast accumulations of sand, but so far from being level it is as full of hills and undulations as many another landscape. The only difference is that the desert hills, instead of being permanent, are constantly changing their shape and position. They are made by the winds that sweep across the sands, and every few months the landscape is quite changed in appearance, owing to the moving of the hills

The deserts have all been made by the winds, for it is the wind that gathers the vast masses of sand together in the one area. Beneath many of the great sand deserts of the world cities and the remains of ancient civilisations lie buried. One of the great problems of countries that border on the desert is that of saving their cultivated territory from the encroachment of the wind-driven sands. Large parts of Persia that are now arid stretches of sand were fertile plains not many centuries ago. The Sahara, with its moving hills of sand, shown in these two pictures, is constantly creeping forward towards the fertile parts of North Africa

writings and carved woodwork and fine architecture and beautiful embroideries, all preserved by the dry sand so that they are as fresh as when they were first buried.

Devastating Dust

When we are told that in a violent sandstorm the amount of dust and sand in the air may amount to 126,000 tons for every cubic mile of air, we need hardly be surprised at the devastation wrought.

The same thing has happened in North Africa, where the sand of the Sahara is ever encroaching on the cultivated lands and human dwellings all round. Many a caravan has been destroyed here by the terrible sandstorms. Nothing resists their march, and this

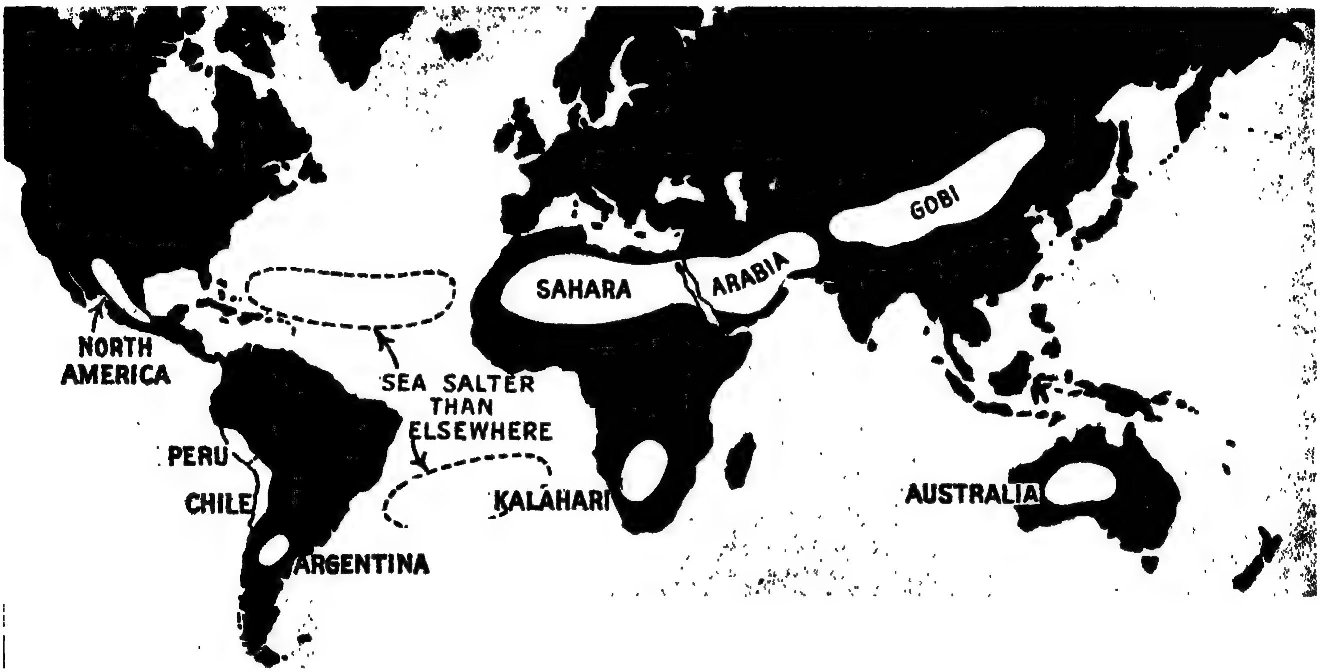
On the coast of Prussia a tall pine forest covering hundreds of acres was totally destroyed by invading sand between the years 1804 and 1827. In New Jersey flourishing orchards have been buried within the lifetime of their owners. Similar examples on a smaller scale are to be found along the coasts of Britain. During the last centry or two, thousands of acres of cultivated land have been buried by drifting sand from the sea, notably along the shores of the Moray Firth and of Aberdeenshire and on the coasts of Norfolk and Suffolk.

Still more destruction has been caused by the moving sand on the shores of the Bay of Biscay. There the dunes march inland at the rate of 60 or 70 feet a year, and nothing can stay their progress. If the mass of

tracts are thus first inundated with water, and then finally overwhelmed under the advancing sand. Roman roads and many villages which existed in the Middle Ages have disappeared. And the same destruction is going on still."

Rocks Sculptured by Sand Grains

When the winds are fierce the amount of sand carried is, of course, greater, and in Central Asia the air is sometimes so full of fine sand and dust that the sun is obscured at midday, and it is necessary to light a lamp in order to read. These strong winds will pick up and carry grains of sand and even small pebbles, and naturally as they are carried forward they wear away any rocks or buildings that may lie in their



There are two great desert belts stretching round the world, and they are shown in this map on Mercator's projection. The northern belt starts with the desert of Gobi, running half across Asia, and is continued by the Persian and Arabian deserts and by the Sahara across North Africa. Then the belt is continued across the Atlantic Ocean, where a great stretch of water is salter than other parts of the same sea owing to increased evaporation. The desert belt is continued across North America with the deserts of the southern United States and Mexico. The southern desert belt is smaller. There is the centre of Australia with its arid reaches, the Kalahari desert of South Africa, a large area of very salt water in the southern Atlantic, and then the deserts of Argentina, Peru and Chile

is found not only in the great desert tracts of Asia and Africa, but in the arid parts of America and even in Great Britain.

Sand hills or dunes, as they are called—dune being only another name for hill—abound over thousands of square miles in the dry plains of Nebraska, Kansas and Wyoming. Enormous expense is incurred from time to time by having to clear railway tracks that in a day or two become buried under the moving sand. Forests of large trees have been buried and destroyed, for although trees make an excellent effort to maintain their life by sending out fresh roots from their branches after the trunks have been buried, sooner or later each tree is covered by the sand.

wind-blown sand is not too great it may sometimes be held for a time by planting certain grasses that bind and hold it, but sooner or later it overwhelms even these.

The Invincible Sands

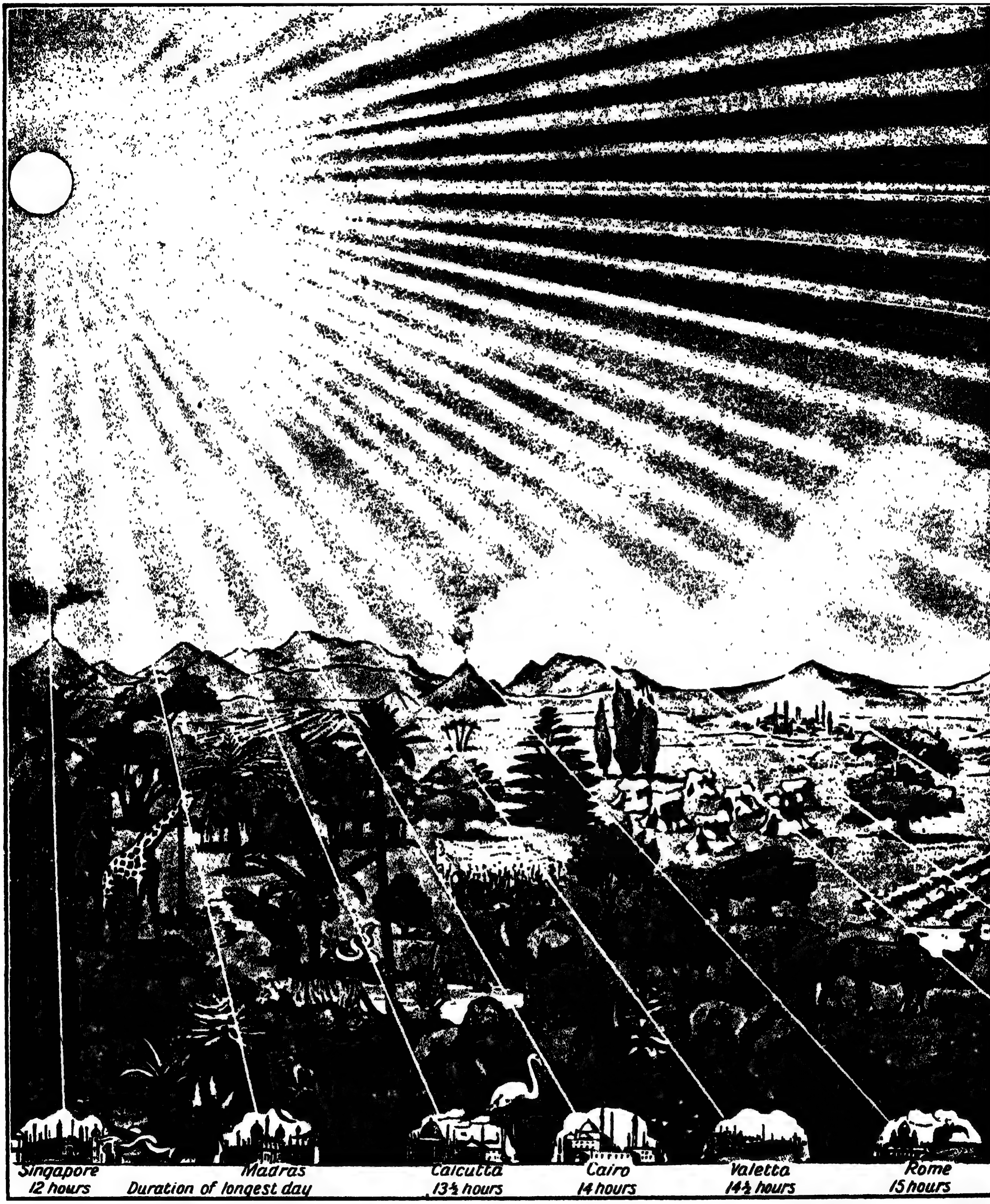
As Sir Archibald Geikie has said of the moving sand dunes, " No barrier, natural or artificial, is able to withstand their progress. Fields, woods and villages are buried in succession. Nor is this all. The sand ridges interrupt the drainage from the interior, and the water collects among and in front of the ridges. Ponds and lakes are formed which, unable to find an exit, are drifting inland along with the sand barriers which dam them up. Large

path. They act as a grindstone or rasp, and where there are rocks in these sand-ridden areas they are sculptured into strange and weird forms by the moving grains.

A great line of sand hills may be piled up one week and may be blown away completely the following week. It may lie in one direction at one time and not many days later lie in an entirely different direction. It all depends on the direction and force of the wind.

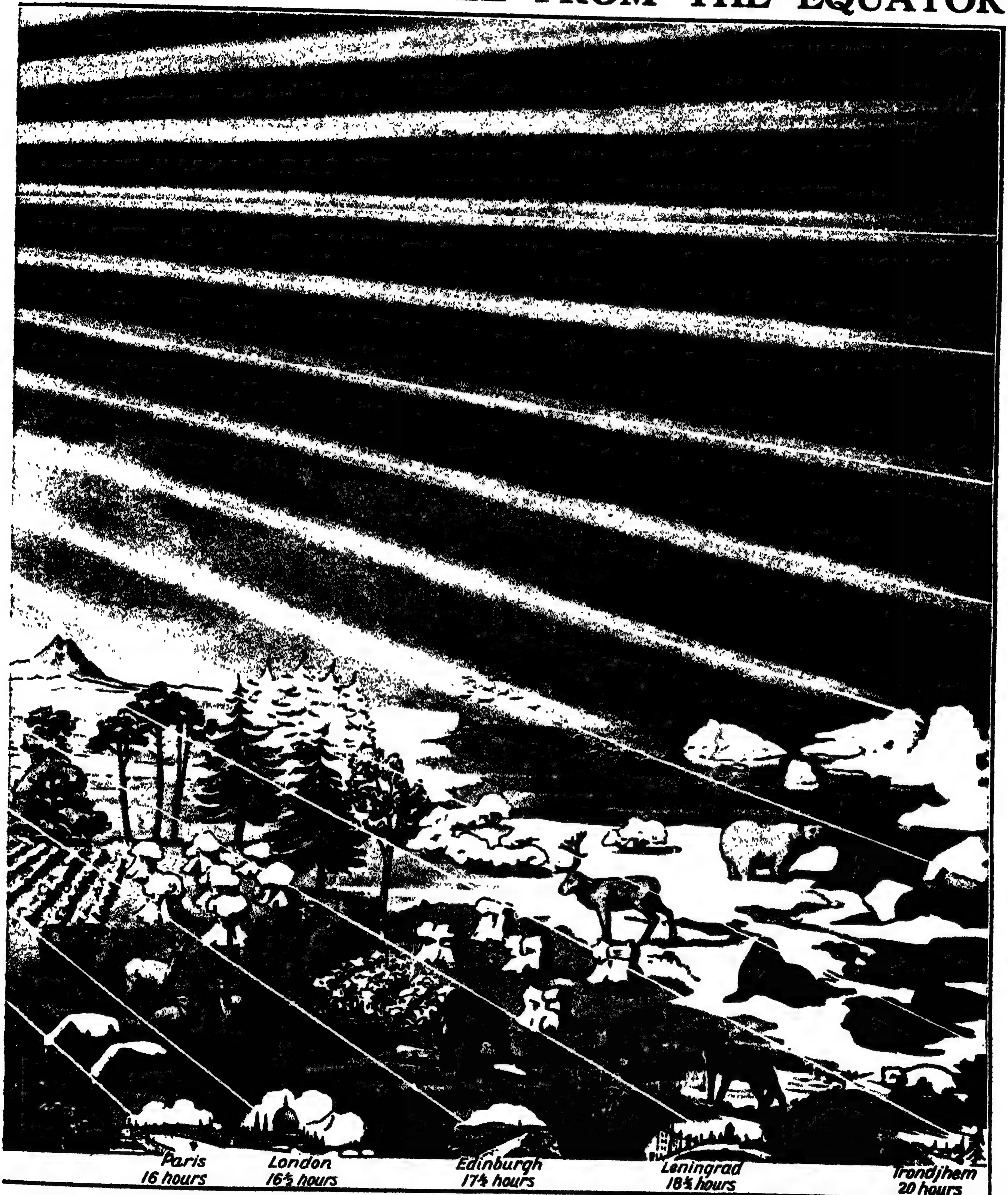
As the wind blows it forms waves and ripples in the sand, exactly as it does in the water, and these are very marked. These ripples, which may only be a quarter of an inch high, are formed in the same way as the great dune ridges.

HOW THE SUN'S RAYS SLANT MORE AND



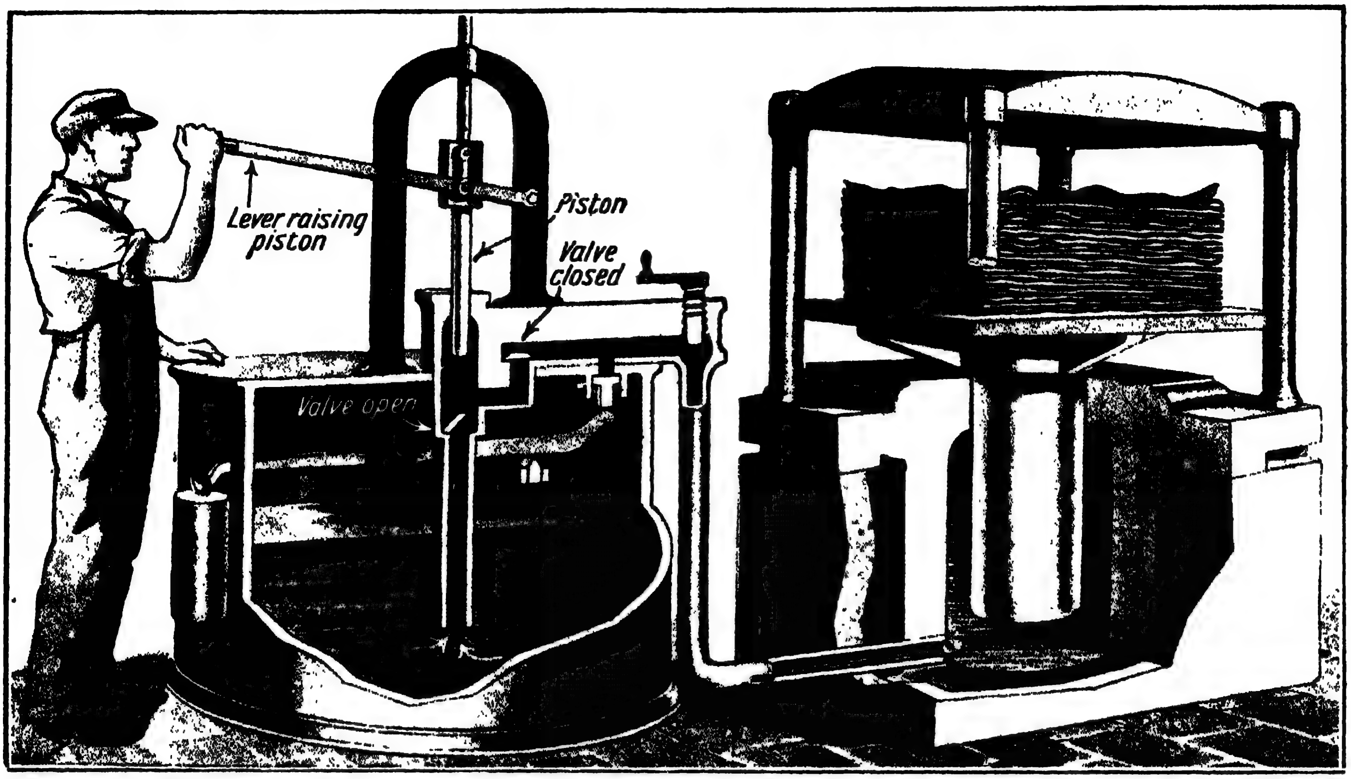
The picture on these pages makes clear why it is that some places are hot and other places cold. Although the Sun shines upon the whole Earth there are differences of temperature due to the fact that the Sun's rays strike some places much more slantingly than others. The cause of the gradual change from warm temperatures at the Equator to colder temperatures at the Poles is due to the fact that the Earth is a globe and revolves in a slanting direction. The slant is such that the central surface, or Equator, is more directly under the rays of the sun, and the rays, after falling on the Equator, then spread outwards so that they become gradually weaker as they reach out to the Poles. The more directly overhead the Sun is, the hotter are its rays, whereas the farther away we get from the Equator, the more slantingly the rays strike, and the less powerful they are, till at last in the region of the Poles they are so slanting as to give

MORE AS WE TRAVEL FROM THE EQUATOR

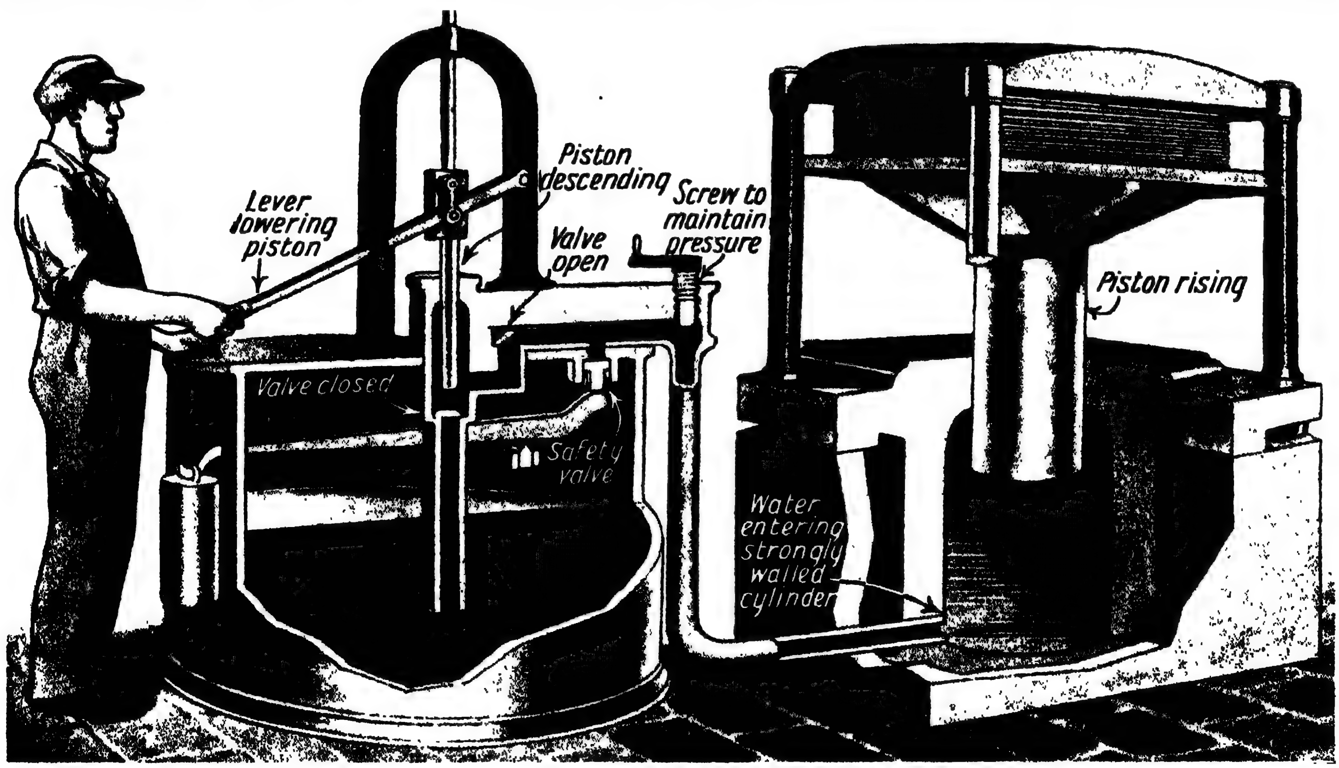


very little heat at all. In this picture a number of well-known cities in different latitudes are shown, and we can see how directly the Sun's rays strike a city like Singapore, and how very slantingly they strike northern cities like Leningrad, and Trondjhem in Norway. It will be seen that the rays fall much more slantingly on Madras and Calcutta than on Singapore. Very few people know that Singapore is the only big and important city that is almost on the Equator. Of course Quito, the capital of Ecuador, is also near the Equator, but, being nearly two miles above sea-level, it has a temperate climate, for the higher we go the colder it gets. Most of the other cities shown are near sea-level, and so the nearer the Equator the greater is their heat. Underneath the name of each town is given the period of daylight on the longest day of the year. The kinds of animals and vegetation that live in the different latitudes are shown

THE WONDER OF THE HYDRAULIC PRESS



These pictures show how a hydraulic press is worked. Its operation is based on the fact that if we press a liquid the pressure is transmitted undiminished in all directions. The hydraulic press consists of two cylinders of unequal diameter communicating by a tube, and these are filled with water under pressure. In the small cylinder shown on the left a piston can be worked up and down by moving a lever. When the piston is raised water is sucked up from a chamber below, passing through a valve, and, entering the communicating tube, surrounds the large piston on the right. The pressure, however, is not sufficient to support this piston and it falls, leaving the press open



When the lever is lowered, and the small piston descends, water is no longer sucked up from the chamber below, but pressure is put upon the water in the communicating tube, and this pressure passes to the water in the large cylinder, pushing up the big piston. This closes the press and presses whatever may be in it as shown on the right. If it is desired to leave the big piston up and the press closed a screw can be turned down maintaining the pressure in the communicating tube. There is a safety valve in case the water pressure should get too great for the metal pipes to sustain

HOW WATER IS MADE TO WORK FOR US

Water power for the generating of electricity is coming more and more into use. All civilised countries which have extensive waterfalls and mountain streams are harnessing these to work turbines and dynamos. But there is another way in which water is set to work in the service of man, and that is in hydraulic engineering. Here we read some interesting facts about the behaviour of water under pressure and its great use in working presses, lifts and other machinery

There are many ways in which water is made to work for us. Very early in the history of man it was made to turn mills to grind his corn, and in more recent times the idea has been developed so that tremendous falls of water, like that seen at Niagara, are harnessed to rotate huge turbines and supply electrical power over wide areas. In the Far East man has even used the power of running water to turn prayer wheels, and thus assist him, as he thinks, in his devotions.

But there is another way in which water has long been made to work for man, and that is by means of its pressure. We have all heard of the hydraulic press, which is explained on the opposite page, and many of us have travelled up and down in lifts which are worked by hydraulic power, that is, by means of water pressure. The word "hydraulic" comes from two Greek words meaning "water" and "a pipe," and it is by sending water through a pipe under pressure that hydraulic machinery is worked, as we shall see later.

A Strange Property of Liquids

Before trying to understand the principle on which such machinery is worked, we must learn something about a curious property which water and other liquids possess. To assist us in understanding this, we may perform a simple experiment.

Let us buy for a few pence a small hollow indiarubber ball. Now let us make a small hole in it and then, squeezing the ball together so as to exclude all the air, hold it under water. As soon as we release our hold the indiarubber ball will fill with water, because the pressure of the air on the surface of the water in the bowl or pail drives the fluid into the ball through the hole.

Now, taking the ball out of the water and placing our finger over the little hole, to prevent the water escaping when we press on the outside, we make a number of other holes with a pin. Having done this we squeeze the ball, and at once water spurts out, not from one hole, but from all the holes alike. In other words, we find that in the case of a liquid, pressure is transmitted equally in all directions.

This, of course, is not the case with a solid. If we put a lump of sugar on the table and press in one direction the sugar will, if it can move at all, go in that direction and in no other.

The great discovery that pressure placed on a liquid contained in a closed vessel is transmitted with the same energy in all directions was made by the great French philosopher, Blaise Pascal. He carried out an experiment which had far-reaching effects on the world, for he showed the way to the hydraulic press and hydraulic lift.

He filled a strong wooden barrel with water, and then in the bung-hole at the top of the barrel he placed a high, narrow tube with a funnel at the top.

A strange experiment that proves a scientific truth of great value to mankind

"Now," said Pascal, "I will burst the barrel by simply filling this small tube with water, that is to say, I will add to the water in the barrel only the weight of this very small quantity of water."

Of course all his friends laughed at him and said it would be impossible. But Pascal, going to the top of a ladder, poured water into the tube and soon it was filled to the top. The water began to come out through the staves of the barrel, which were pressed out as though by great force from inside.

The other scientists were astounded, but Pascal then explained the discovery he had made. The pressure on the water in the barrel did not depend upon the total weight of water above it, but upon the weight pressing on the small area of the tube where it entered the barrel.

A Paradox of Science

In other words, if a tube in such an experiment has an area of one inch, and the water in the tube weighs, say, five pounds, the pressure of the water in the barrel is equal to five pounds on every square inch of its surface.

To put it another way, the walls of Pascal's barrel had to support the same pressure as if they had been surmounted by a mass of water with a base equal to the bottom of the barrel and a height equal to the length of the column in the tube. It is not surprising that men of science were so puzzled that they gave this rather remarkable fact the name of "the hydrostatic paradox." A paradox is something which is true, but nevertheless seems to be absurd.

As we can see by the picture on the opposite page, it is this paradox which is so very useful to man, for the pressure of a pound of water can produce in this manner the same effect as a ton or several tons. It results from the fact that a liquid can be compressed scarcely at all, that is, when great pressure is put upon it, it still occupies almost the same space as it did without the pressure.

This, of course, is not the case with a gas, which can be compressed very much indeed, nor is it true of a solid, for with sufficient pressure a solid can be squeezed into a much smaller space.

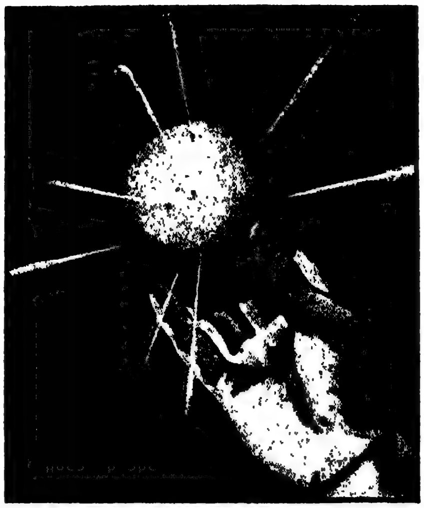
It used to be thought that a liquid could not be compressed at all, but later experiments proved that there was a slight compression, though it is so small as to be scarcely worth considering.

For instance, with a pressure equal to that of the atmosphere, namely, 14·7 pounds on every square inch, water is compressed only one 20,000th of its original volume.

The sea water at a depth of a mile has an enormous weight upon it, but it is squeezed into a space only one 130th less than it would occupy at the surface of the sea. In any case, liquids are perfectly elastic, for no matter what the pressure may be to which they are subjected, they always regain their original volume the moment the pressure is removed.

This property of water and other liquids of transmitting pressure equally in all directions is used enormously all over the world to-day. A vast quantity of machinery, for example, in London and other large cities is worked by hydraulic power.

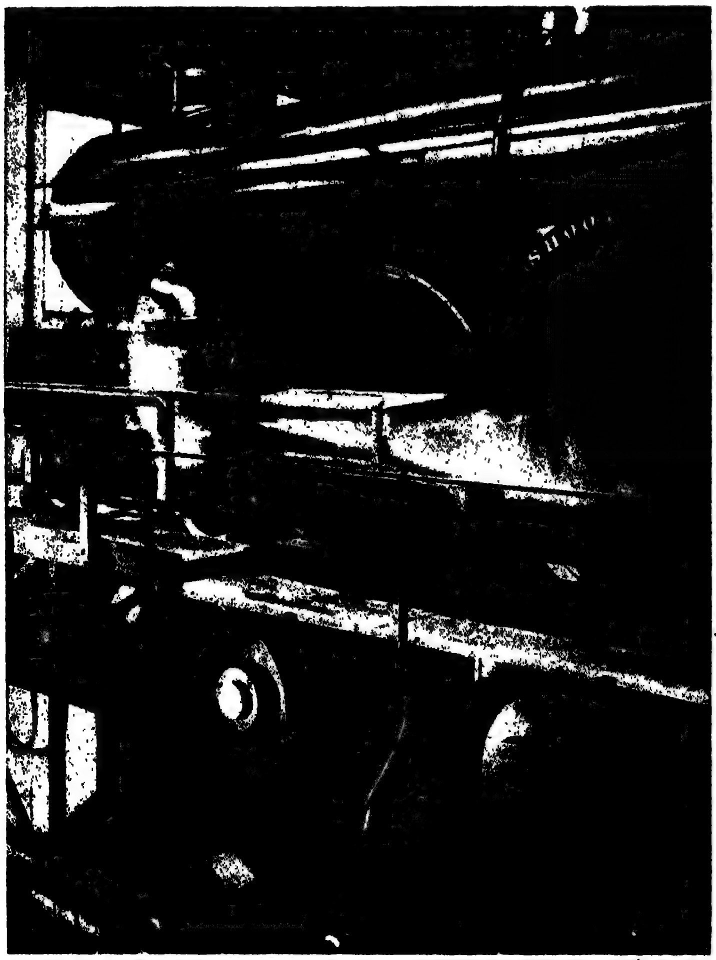
There are in London itself, under the roadways, nearly 200 miles of water-mains, where the water is under high pressure. These mains are, of course, quite distinct from the water-mains which carry water for drinking and washing. They are found in all the busiest streets, and run from one end of industrial London to the other. From these mains the water under pressure is carried into warehouses and factories and offices to work the lifts, baling-presses and other machines.

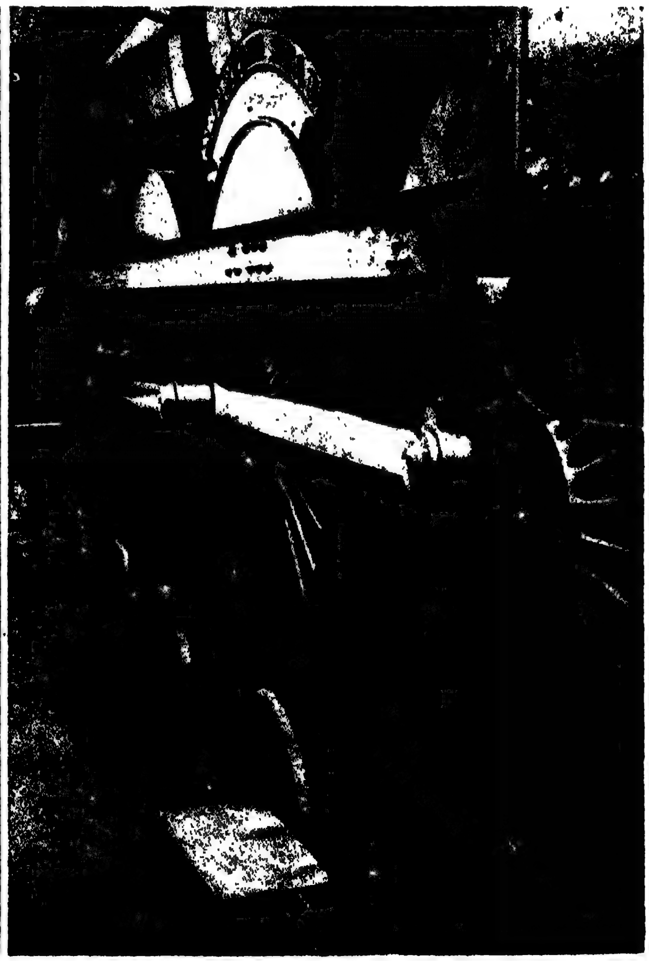


A simple experiment to show that water presses equally in all directions. It is this valuable power of water that is utilised by man in the hydraulic press

Few people know that there is such a wonderful service of hydraulic power in London, and in some other large cities. It is always available, and the water is at the enormous pressure of 700 pounds to every square inch. About thirty million gallons of water at this pressure are pumped every week for engineering purposes, and it can be understood that when a small pipe in a hydraulic press transmits such enormous pressure to a chamber with a large surface of water, the work it does is very great indeed. The possibilities of the hydraulic press are only limited by the strength of the pipes which carry the water in the machine.

TRAVELLING AT FULL SPEED WHILE STANDING STILL





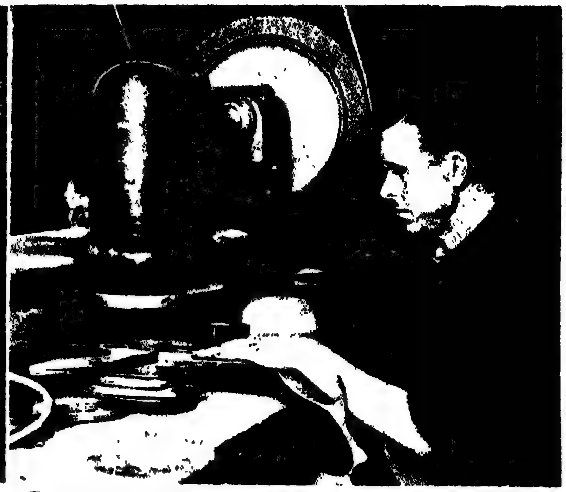
Most railway authorities have equipment for testing the running of express engines without the engines having to move. These two photographs show the testing machinery used by British Railways for judging the running efficiency of its locomotives. The engine is run on to a series of rollers which are turning rapidly in the opposite direction to that which the locomotive faces. Then the engine is set going at full speed, but as the rollers on which the wheels turn are moving at the same speed, the engine does not go forward. A speed equal to 85 miles per hour has been attained in this way without the engine travelling an inch. It is a very ingenious and useful device and gives full information as to the coal and water consumption of an engine and its pulling power at high speeds

HOW THE WINDMILL GRINDS THE CORN

Windmills are not such familiar landmarks in England as they used to be, but there are still a number which are working. Here we see how the windmill grinds the corn. Two different types of mill are shown. The one on the left is known as a smock mill and only the top moves round. It is also called a Dutch mill, because it is the kind most often seen in Holland. The one on the right is known as a post mill, because the whole mill revolves on a stout post. Of course it is necessary that either the mill or the top of it should move, so that the sails can always be in the right direction for the wind. The sails, by a series of cog or toothed wheels, some of which are called baskets and trundles, turn the grinding stones. The machinery, including the wheels, in a windmill is mostly made of wood

HOW OUR BOOTS AND SHOES ARE MADE

In factory-made boots and shoes the uppers are first cut out from the skin by knives running round metal patterns, and the different parts of the upper are then pasted together, and sewn by machine, as is being done here



The soles are cut out from the thick hide by a shaped knife on which a powerful press descends. A number of soles already cut can be seen on the bench

The upper when complete is drawn over a last and fastened to the insole by an exceedingly complicated lasting machine

The outer sole is sometimes sewn on direct, while in other boots a strip of leather called a welt is first sewn on, as is being done here

The boot then goes to another machine, which sews the outer sole to the welt with waxed thread

Meanwhile the heels have been cut out and built up, and are brought to this machine and nailed to the boot

Heels and soles are next smoothed by revolving wheels covered with sand-paper, and blackened and polished

Expensive boots and shoes are still made by hand. Here we see a bootmaker hand-sewing the sole to the welt with waxed thread

The third and fourth Pictures are reproduced by courtesy of Messrs. J. Sears & Co., Ltd

ROMANCE of BRITISH HISTORY

THE FIRST ENGLISH PRINCE OF WALES

For hundreds of years the Prince of Wales has always been the heir apparent to the English throne, but the very first of the English princes of Wales was not the king's direct heir. Here is the interesting story of the first Englishman to be proclaimed Prince of Wales

After John's death his son, Henry, mounted the throne, but he was a very little better king than his father. Although he was very religious he was faithless, passionate and stubborn, for in those days religion and morality had very little to do with each other Some of the worst men of the Middle Ages were the most religious, and even the princes of the Church were sometimes men of questionable character.

Henry attended Mass regularly, loved ecclesiastical ceremonies, endowed abbeys and churches, and even kissed lepers, but he was a bad king in every sense of the word. He filled the offices of state with his foreign relations who oppressed the people, and he wasted the taxes exacted from his subjects.

Although at his coronation as a boy he had sworn that he would show strict justice to the people, abolish bad laws, and make good ones, the oath had no more weight with him than if it had never been taken. Indeed, it has been said that his son, Edward the First, was the first king since William the Conqueror to keep his word. Before that, oaths and promises were made only to be broken.

A King in Debt

Henry was always very generous with other people's money, and when his sister, Isabella, married the Holy Roman Emperor, he gave her such costly and handsome presents that an old chronicler tells us that "they appeared to surpass kingly wealth."

The result was that Henry was left in debt, and so at last, when there was no other way of getting money he was obliged to summon his nobles, and they made him ratify once again the Great Charter which his father had sealed. Then they gave him the money he asked for, but he frittered it away, and five years later wanted more.

The nobles were now very angry. They banded together under Simon de Montfort, the Earl of Leicester, who had married Henry's sister, to resist the King. A battle was fought at Lewes, and Henry and his son, Prince Edward, were made prisoners. The outcome was the first real parliament in our modern sense. It met at Westminster in January, 1265. Not only were the barons and the knights of the shires summoned, but now the inhabitants of the large towns were called on to elect men to represent them in parliament, and to look after their interests.

The Franchise, as it is called, that is the freedom to vote for members of parliament, has been extended many times till now it includes practically all citizens, male and female, of 21 and over. But in principle the parliament is the same as that which was summoned in Henry the Third's reign.

Eleanor sucking the poisoned wound of Prince Edward at the siege of Acre

Later on the captured Prince Edward escaped, raised an army and fought a battle at Evesham in which he was the victor. He rescued his father, and his uncle, Simon de Montfort, was slain. "Thus ended," writes an old historian, "the labours of that noble man, Earl Simon, who gave up not only his property but also his person to defend the poor from oppression, and for the maintenance of justice and the rights of the kingdom." We should always remember with honour Simon de Montfort, for his great work for good government was never undone, though unfortunately he died in defeat.

Soon afterwards Henry himself fell ill, and died, but his son and heir, Prince Edward, was away in Sicily, returning from the Seventh Crusade. After Simon de Montfort's death, young Edward, who had married a good and beautiful woman, Eleanor of Castile, had decided to join his uncle, King Louis of France, in trying to win back the Holy Land from the Saracen.

Edward was a great contrast to his father. He was one of the noblest and greatest of the English kings. He loved his people and his people loved him. Of course, he was not perfect, for no man is, but he was a man who could be trusted and, further, he drew the admiration of all because he was tall and handsome and brave and clever and affectionate. He married twice, and both his wives were among the finest queen consorts that England has ever had, and Edward loved them truly and was very faithful to them.

A Dramatic Scene

Eleanor accompanied Prince Edward to the Holy Land and there is a beautiful story told of how she saved his life. He was besieging Acre and the Emir of Joppa, who was the Saracen admiral, pretending that he was anxious to become a Christian, sent a messenger with letters to Edward. This he did on several occasions, until Edward really believed that the Emir was in earnest. Then one day on the fifth visit the messenger was introduced into Edward's tent.

The Prince was suffering from a heat stroke, and was lying on his bed scantily clothed. The emissary handed the letters to Edward who began to read, and then the man, pretending that he had still another very secret paper to deliver, desired that he and the English prince might be alone. The tent was cleared, the assassin drew out the letter from his bosom, but with it he drew a poniard, and in a moment aimed a blow at the side of the Prince.

Fortunately, Edward raised his arm, and that received the blow. When his assailant tried to repeat the stroke Edward felled him to the ground with

a kick, and as the traitor returned to the attack the Prince hit him with a footstool.

Attendants rushed in, but the assassin was already dead. Some say he was struck by the blow of the stool, and others that he was stabbed with his own dagger.

Fearing that the dagger was poisoned it is said that Eleanor sucked the wound, but of this we are not quite sure. After some days, however, the wounded arm began to show unfavourable symptoms. The flesh blackened and there were signs of mortification. All those round the Prince began to look very worried and speak in low tones about what might happen.

"Why whisper ye thus among yourselves?" said the Prince. "What see ye in me? Tell the truth and fear not."

Then a surgeon recommended that the wound should be cut, an operation that would be very painful. "If suffering," said the Prince, "may again restore my health, I commit myself to you. Work on me your will and spare not."

A Devoted Queen

Eleanor remained by the Prince's bedside all through the crisis. Then at last she broke down, and Edward asked his brother Edmund and a knight to carry the Princess away. At this she struggled and cried, as she wanted to be with her beloved husband, but her brother-in-law told her that it was better she should scream and cry than all England mourn and lament. The operation was performed and proved successful. In fifteen days Edward had sufficiently recovered to mount his horse, but it was a long time before he became quite well.

The Prince's army was now greatly reduced by sickness and desertion, and feeling it was no use to remain longer in Syria he left and started on the journey back. As already mentioned, they had reached Sicily when news came of King Henry's death, and, greatly upset, the Prince and his wife returned to England.

Edward and Eleanor were crowned in Westminster Abbey, and then a royal feast was held. It was a feast indeed. Among the good things provided were 380 oxen, 430 sheep, 450 pigs, 18 wild boars, for there were still wild boars in England at the time, and more than 19,000 fowls. During the festivities the aldermen of the City of London threw handfuls of gold and silver amongst the crowds. The conduits or water fountains ran with white wine and red, and Edward and his followers let loose 500 horses on which they had ridden to the banquet, so that anyone in the crowd might seize them and claim them for his own.

From the first the new king was greatly loved, particularly for his knightly qualities. The people remembered his gallant behaviour to a famous robber who, like Robin Hood, lived in a wood and was reputed to be very strong and brave. The man's name was Adam de Gordon, and Edward longed to fight him in single combat. He went to the wood with a band of followers, and there came across Adam with his men. Instead of allowing the two little armies to have a battle, he called on the robber chief to fight it out single handed.

There was a long conflict and finally the Prince vanquished his opponent, but he was so pleased with the skill and bravery shown by Adam that he promised him his life and a good fortune. The robber turned out to be a gentleman by birth, who, during the wars of the previous reign, had lost all his property and had in consequence taken to a roving life. Edward kept his word, restored his property to Adam de Gordon, and introduced him to his wife and his father, the King, who was then alive.

Waltham Cross, one of the memorials set up by Edward I to Queen Eleanor

A Fine Old English Ballad

There is a fine old English ballad that tells the story in verse. The vanquished robber is presented to Eleanor and to the King, and then

"My child arise," the old king said,
And a tear was in his eye,
He laid his hand on the Prince's head,
And he blessed him frequently;
"With a joyful heart I grant your prayer,
And I bid the Gordon live;
Oh! the happiest part of a monarch's crown,
Is to pity and to forgive."

On coming to the throne, Edward proved a good king whose word could be trusted. He summoned a parliament of lords and commons in 1275, and it is interesting to remember that it was this parliament which passed the First Statute of Westminster, a measure embodying and extending Magna Carta.

In 1931 was passed another Statute of Westminster which restated in legal terms what was agreed at an Imperial Conference a few years earlier, that the Parliament of Westminster is no longer the Imperial Parliament. It affirms that "No law hereafter made by the Parliament of the United Kingdom shall extend to any of the Dominions as part of the law of that Dominion, otherwise than at the request and with the consent of that Dominion."

Returning to the subject of Edward, we must remember that governing England by Parliament was only one of his cares. He was not the acknowledged sovereign of Great Britain, as our King is to-day. Both Wales and Scotland were, at that time, hostile countries. The Welsh, although their princes did homage to the English king, were very troublesome neighbours, and were fond of fighting.

Britons and Saxons

They were really descendants of the Ancient Britons who had been driven into the mountain fastnesses of their country and they hated the English, whom they regarded as "Saxons." When Edward came to the throne they had a brave and clever prince, named Llewellyn, who took no notice of the summons to come and do homage to the new king. After sending for him again and again, Edward at last lost patience and marched with an army into Wales.

There was some fighting, and in the end Edward conquered the Welsh and killed their prince. Llewellyn's head was cut off and sent to London, where it was crowned with a wreath of willow and set up on the Tower of London in mocking fulfilment of an old Welsh prophecy that a prince of Wales should be crowned in London. The Welsh people had hoped that Llewellyn would be the prince in question.

Now that their native prince was dead, Edward decided to present a new prince to the Welsh people, who should be a link between the two nations.

Henceforth the Prince of Wales should be an English prince.

Edward built a new Castle at Carnarvon as a stronghold which should help to keep the Welsh in order. It looked then very much as it does now, and to this castle Edward carried his beloved queen. There in the Eagle Tower, at a great height from the ground, her son Edward was born in a little chamber 12 feet long and 8 feet broad, and without a fireplace. A Welsh nurse was provided for the infant, and when a Welshman carried the news to Edward at Rhuddlan Castle where he happened to be staying, he knighted the Welshman on the spot and gave him a grant of land.

He then hastened to Carnarvon, and when the chiefs of North Wales came there to give their final submission they asked Edward to appoint them a prince who was a native of their own country and whose native tongue was neither French nor Saxon, which they could not understand. Edward told them that he would immediately appoint a prince who could speak neither English nor French.

A Prince for the Welsh

The Welsh chiefs, expecting they would be given a member of their own royal line, declared they would accept the King's nominee as their prince if his character were void of reproach. Thereupon the King ordered his infant son to be brought in and presented to the chiefs, assuring them that "he had just been born a native of their country, that his character was unimpeached, and that he could not speak a word of English or French, and that, if they pleased, the very first words he should utter should be Welsh."

Little did the fierce ministers expect such a reply, but they had no alternative but to submit with a good grace, so they kissed the tiny hand presented to them and vowed fealty to Eleanor's babe.

Edward I presents the first English Prince of Wales to the Welsh

At this time the new prince, who was to become King Edward the Second, was not the heir to the throne, for Eleanor had an elder son named Alphonso, after her brother, Alphonso the Tenth of Castile. But a few months after Edward's birth Alphonso died, and so Edward became the English heir apparent. It is interesting to speculate that if Alphonso had lived and become king that strangely foreign name might easily have become one of the most popular English Christian names, as Edward has since become.

When Queen Eleanor died all England mourned her, and an old historian speaks of her as "a pious and modest woman, merciful to the English, loved by all, a support of the kingdom."

King Edward knew not how to bear his grief. He escorted her body from Grantham to Westminster Abbey, and wherever the body rested for the night the King raised a wayside cross. Three of these Eleanor crosses still exist—one at Hardingstone, near Northampton, one at Geddington, and one at Waltham Cross, by Epping Forest. The last resting place before the body reached the Abbey was the village of Charing, the site of which we now call Charing Cross because of the Eleanor Cross set up there. This has disappeared, but a replica of it is to be seen in the yard of Charing Cross Station.

Edward always spoke of Eleanor as his "chére reine," and some people have supposed that the name Charing Cross really means chére reine cross. This, however, is not so, as the village of Charing was so named long before Eleanor died. It was probably called after some ancient Saxon chieftain named Ceorra.

Edward married again, and, most fortunate of kings, his second wife was a woman of lovely character like his first. She was Marguerite, daughter of the King of France. She was kind to her stepchildren, and always interceded for the young Prince of Wales when he angered his father. She constantly obtained the pardon of debtors and other prisoners, and even the goldsmith who had made the golden crown for Robert Bruce of Scotland, and was therefore regarded by Edward as a rebel, was pardoned at the Queen's request after being sentenced to death as a traitor. "We pardon him," says Edward the First, "solely at the intercession of our dearest consort Marguerite, Queen of England."

The English chroniclers record no single fault or folly of this admirable queen, and one declares that she was "good without lack."

A King to be Proud Of

Edward fought various wars in Scotland to subdue its stubborn people, and he finally died while on an expedition to the north. He had been named by his Scottish enemies Longshank, and the name has stuck to him ever since, but why it should have been given no one can say. Though tall, he was certainly not lanky, but had a fine figure. He wore plain clothes, enjoyed field sports, affected little ceremony, and very rarely wore his crown.

When there was need he worked as hard as any of his soldiers, sharing their food and even trundling a barrow in the making of fortifications. Once when his convoys had been captured in Wales he refused the single flagon of wine which had been left, saying that he and his soldiers must have everything in common. "We will all share the same diet," he declared, "until God looks on us again, nor will I eat better than you."

Edward the First was a monarch of whom England may well be proud. It has been said that he assisted the march of liberty and that he encouraged the advance of the people in their path to power. He may have done so largely because he thought it would help to check the arrogance of the nobles, but, nevertheless, the nation as a whole benefited.

He has been given the name of "The English Justinian," and that is a high tribute, for Justinian was the emperor whose reign was the most brilliant in the history of the later Roman Empire, and has left a fine record as an able ruler and an upright man.

WANTED AND UNWANTED EXPLOSIONS

When a big explosion occurs unexpectedly it brings ruin and disaster. This photograph shows the result of such an explosion. It occurred below ground in a coal mine in Germany, and resulted in the deaths of hundreds of miners and vast damage even at the surface

This explosion is not the result of an accident, but of intention. A heavy charge is being fired to blow away part of a hill for the making of a road. To do with hand labour the work that this explosive has done in a moment or two would have taken scores of men many weeks. Explosions of this kind are particularly useful in quarries and such places where a mass of many tons of rock has to be moved

MARVELS of CHEMISTRY & PHYSICS

WHAT AN EXPLOSION REALLY IS

An explosion is only the same kind of chemical reaction that happens when a candle burns. The difference is that with the burning candle the combustion or chemical changes take place slowly, while in an explosion they take place very rapidly. In these pages we see how an explosion which often causes trouble can be harnessed for use. The type of explosion caused by the release of atomic energy is dealt with elsewhere in this work.

We sometimes read of an explosion in a coal mine, or of a gun or bomb exploding with the loss of many lives, and we naturally come to associate the word "explosion" with something terrible and disastrous. A great building or a big ship may be blown up, that is, it may be utterly destroyed in a moment.

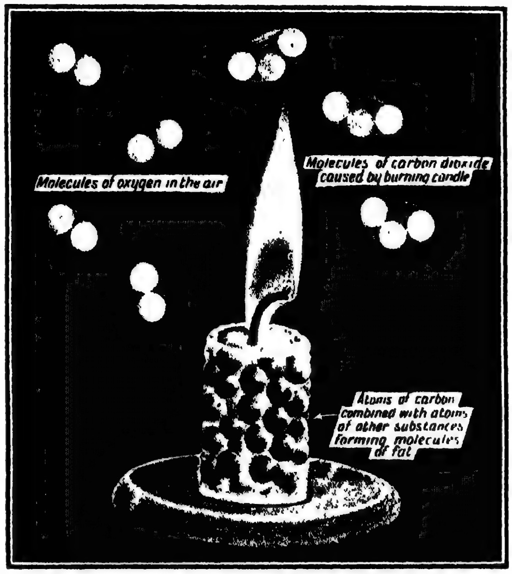
What exactly causes this, or in other words, what is an explosion? It is very interesting to remember that all explosions are not disastrous. Indeed, modern life would be quite impossible if it were not for explosions which are used in the service of man.

Useful Explosions

The motor-car or motor-bus in which you go to school can only move because of a constant series of little explosions in the engine. These explosions drive the pistons to and fro so that they will make the wheels go round and carry the vehicle forward.

The man who goes out to shoot birds or rabbits is only successful because he causes a little explosion inside his gun. On a larger scale the quarryman breaks up the rock so that it can be taken away for building purposes by causing an explosion in a crack, thereby separating large pieces of the stone from the main rock itself.

Sometimes when you are in a room and a coal fire is burning in the grate, there is a loud bang and a little piece of cinder is blown out on to the hearth-rug. You pick it up quickly and throw it back into the hearth, so that it shall not burn the rug. The cinder was thrown out of the fire by an explosion in the fire itself.



When a candle burns atoms of carbon from the molecules of matter in the candle are released by heat and combine with atoms of oxygen from the molecules of that gas in the air, forming molecules of carbon dioxide

On November 5th, when we have a good time in the garden with fireworks, we see a whole succession of explosions, these causing the sparks and balls to fly out of a Roman Candle, a Catherine wheel to go round, and a rocket to go up in the air and with a loud bang scatter sparks all round.

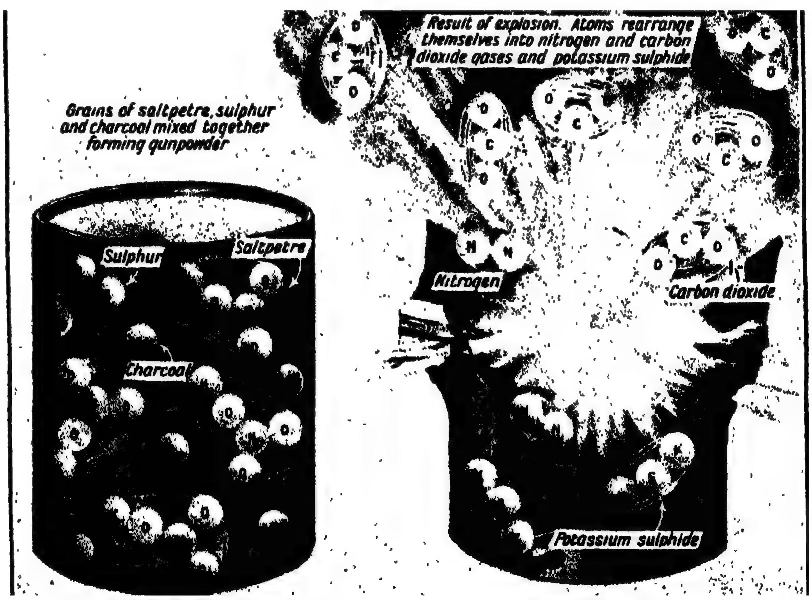
The Burning Candle

Now let us see what happens when an explosion takes place. Take a candle and light the wick with a match. At once there is a steady flame, which goes on burning so long as you do not blow it out. But as it burns the candle gets shorter and shorter. Why is this, and what is happening during the burning of the candle?

Michael Faraday, one of the greatest scientists that have ever lived, wrote a whole book for children on the chemistry of a candle, and in this he explains that when the candle burns, some of the oxygen in the air, the gas which is necessary for our lives, combines with carbon in the candle, and forms a gas which is called carbon dioxide, the old name for which was carbonic acid gas.

It is the heart of the flame which causes these two substances, or elements, as the chemists call them, to combine and form the new substance, which chemists call a compound.

It is no use trying to form carbon dioxide gas by simply mixing carbon with oxygen. The heat is needed, and then something happens. The molecules of carbon



When gunpowder explodes the same kind of thing happens as when the candle burns, only the changes take place rapidly. Gunpowder is made up, as shown on the left, of molecules of sulphur, saltpetre and charcoal or carbon. Saltpetre is composed of molecules containing potassium (represented by the symbol K), oxygen and nitrogen. When the gunpowder explodes the atoms rearrange themselves into carbon dioxide and potassium sulphide, while the nitrogen of the saltpetre is released. This all happens very suddenly

and the molecules of oxygen are broken up, and the atoms of which both molecules are formed combine in another way, so as to form a new kind of molecule, that is, the molecule of carbon dioxide. This process is called combustion, or burning.

Combustion and Explosion

It does not go on very quickly in the burning of the candle. It goes on still more slowly in what is known as a slow combustion stove, that is, a closed-up stove in which we burn anthracite coal or coke. The process is even slower when a haystack becomes wet, the burning or combustion caused by the action of the water and the air and the hay on one another being very slow indeed, but eventually enough heat may be produced to cause the haystack to smoulder or even burst into flame.

When a stack of coal is left in the open air, as is often the case on railway premises and in coal yards, a certain amount of combustion goes on. It is so slow, however, as to be almost unnoticeable.

But now let us go to the other extreme. Some gunpowder or cordite is put into a gun and fired. This is combustion, but it takes place so rapidly that the new gases formed have no time to escape gently, as they do in the case of a burning candle, or a coal fire, and therefore they emerge from the muzzle of the gun with a mighty rush.

If gunpowder is burned in an open space it burns very much like any other material, such as paper or shavings. The gases formed can get away in all directions. The explosion occurs when the gunpowder or other explosive material is put into an enclosed space, as in a cartridge, a gun, or a detonating charge in a quarry.

The shattering effect of an explosion is due to a sudden and enormous increase in pressure owing to the rapid expansion of the gases formed.

An explosive has been described as "an unstable system which undergoes spontaneous transformation within an almost infinitely small period of time," and this is a good description.

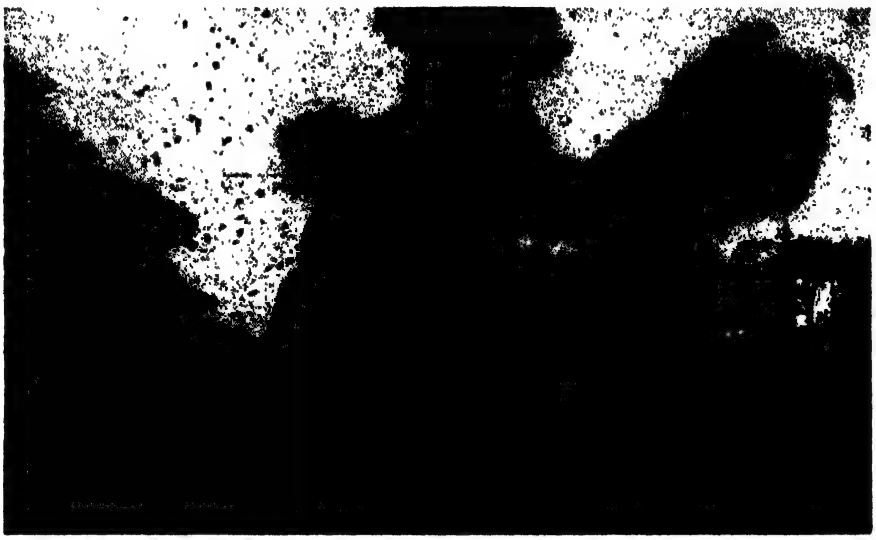
The elements of which the explosive compound is formed are held together so insecurely that they are very easily and quickly set free and made into other combinations. The change is said to be spontaneous, a word from the Latin meaning "of one's own accord," because the explosion is produced with very little effort—a tap or the application of a little heat.

We may regard as an explosive, then, a substance whose molecules are in unstable equilibrium. The least thing will upset them, just as an egg balanced on its end is easily knocked over. Some explosives are less sensitive than others, and it takes a greater effort to make them explode.

Effect of Blast

Explosives seldom do their greatest damage at the actual point of explosion, but at some distance away. This is due to the property called blast.

Blast is produced by the sudden liberation into the air of large volumes of gas expanding at high pressure, so that great quantities of air are suddenly pushed about in various directions from the centre of the explosion. The displaced air creates pockets or hollows in which it is sometimes pushing and sometimes sucking.



Far more explosives are used in peacetime than in wartime, and this photograph shows an old railway bridge being blown up as the quickest way to make room for a new one.

An explosion creates a pressure wave which travels at about 1,100 feet per second and pushes against any object in its path. When the pressure wave has passed, the atmospheric pressure returns to normal, but in doing so creates a partial vacuum which acts as a sudden pull on the objects in the vacuum. Although the pulling effect is weaker than the pressure or pushing effect, it lasts several times longer and does much damage to objects which did not have time to weaken when struck by the shorter-lasting pressure wave. Often the pull exerted by the vacuum does the greatest damage; and its effects can always be recognized by the circumstance that windows and walls destroyed by blast generally fall outwards towards the source of the explosion, rather than away from it.

If the pressure wave lasts long enough, objects in its path begin to shake violently; and while they are shaking they are pulled down by the pulling effect of the vacuum created by the return of the atmosphere to normal. Objects built of timber or having many joints vibrate much more rapidly than stone or concrete objects, therefore these solid structures are better able to withstand blast.

It is the dual push-and-pull action of blast on obstacles in its path that produces contradictory effects. Thus, in a number of buildings in a blast area, some may be destroyed by the initial forward movement of the pressure wave and fall before it, while others will collapse under the pull-effect and fall in the opposite direction. Although the suction is weaker than the original pressure, it lasts several times as long, and normally does much damage to objects which had not time to weaken under the usually brief first pressure.

Blast generally spreads outwards, with a steep incline at the point of the explosion, but quickly curves back towards the ground. This explains why objects in the immediate vicinity of impact may be unaffected while buildings some distance away will collapse.

Animal and human victims of blast are killed either by the concussion of the initial pressure wave, or by the pulling effect created by the resultant vacuum. In the latter case the air is extracted from the body; the lungs collapse and the internal organs break up.

There are many curious things about explosives as compared with non-explosives. For instance, if we mix porous carbon with liquid oxygen, the mixture is explosive, and as a result of the explosion carbon dioxide gas is formed. But if we take liquid carbon dioxide and let it change into the gaseous form, there is no explosion. In both cases the chemical elements concerned are the same.

The explanation is simply that in the first instance the production of carbon dioxide gas is accompanied by a great development of heat, which hastens the process, whereas in the second instance the changing of liquid carbon dioxide into gas, instead of producing heat, results in a great absorption of heat.

A great chemist, Dr. H. Brunswig, sums up the matter by saying that a material which requires decided energy

to enable it to undergo a change from its initial conditions possesses no explosive properties, but a material that can be so changed that a great development of heat is made possible is explosive.

A very little thing may cause a very big explosion. How many times some foolish person goes to look for an escape of gas in a house with a lighted match. Of course the heat of the match fires the gas and an explosion may wreck the building, possibly with fatal consequences.

Explosions sometimes occur in mills and grain elevators. There is a sudden flash, a loud report, and the walls are blown out, and often the building is set on fire. The cause of these explosions was for a long time a mystery, but it is now believed that the explosion is set going by a spark or sparks of electricity generated by moving parts of the machinery on a dry day.

A really useful explosion : a derelict steamer which has become a menace to navigation is being blown up

The dust of flour and grain and coal is highly inflammable, as also is petrol vapour. We know that the petrol vapour in the motor engine is exploded by an electric spark, and if that explosion on a small scale can be caused by a spark, there is no reason why a greater explosion should not be caused in exactly the same way. A very little friction will cause an electric spark, as when we comb our hair or stroke the cat's back, and even when we walk across a carpeted floor on a dry day we may generate sufficient electricity to make a spark jump from our finger to any metal or other conductor that may be handy. Probably in some such way the mill and mine explosions are often caused.

It is, of course, difficult to guard against such explosions, but they may be prevented by spraying the floors and walls with water. Electricity is not easily generated where there is damp.

HOW WE MEASURE THE TEMPERATURE OF A BODY

When we want to know how hot or how cold the air is, we look at the thermometer, and if we want to test the bath water we put a thermometer into it to see if it is too hot or too cold. When we are ill, also, the doctor puts a thermometer into our mouth to see if our body is hotter than it should be.

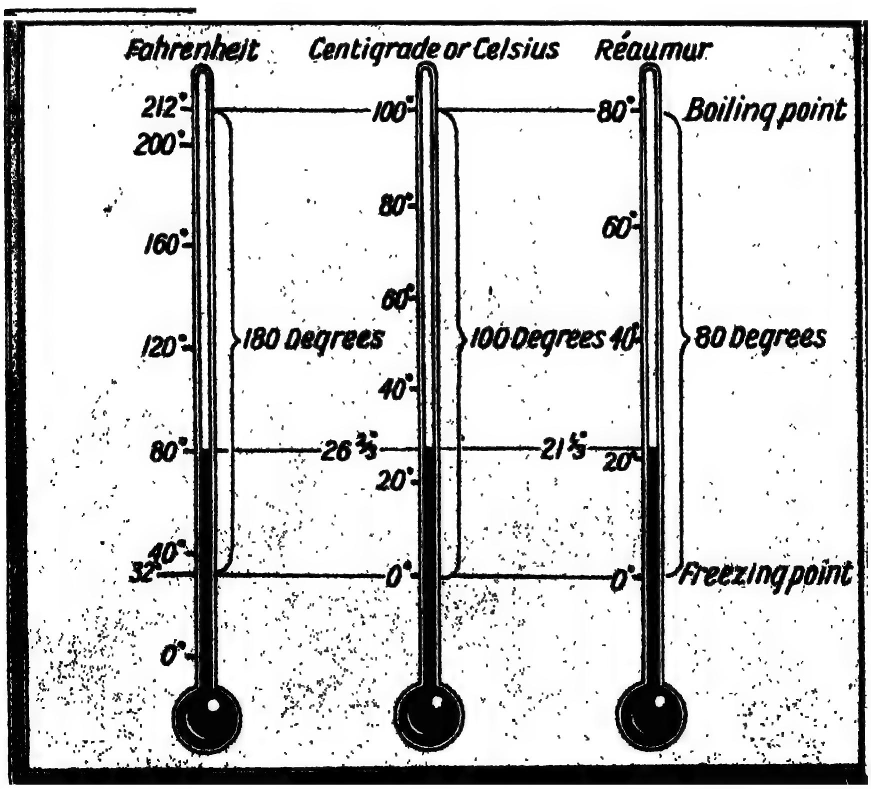
Now what is temperature and what is a thermometer? We must be clear from the beginning that temperature is not heat, for two bodies of equal size and weight may have the same temperature, and yet contain quite different quantities of heat.

When we use a thermometer to find the temperature of a body we are not measuring its heat, but its heat-level. Temperature has been defined by the scientists as a condition or state of body which is changed by the gain or loss of heat. When we have two glasses of water of different temperatures, the one that is hotter is really at a higher heat-level than the colder water. If we had two vessels containing equal weights of water at different temperatures, and then mixed these together the temperature or heat-level of the hot water would fall, while the temperature of the cold water would rise, and the temperature of the mixture would be midway between the original temperatures of the two.

We must have some standard by which to measure temperatures and this the thermometer provides. But all thermometers are not alike. For all ordinary purposes what is known as the Fahrenheit thermometer is used. In this a tube containing mercury or coloured alcohol is divided into 212 degrees. Boiling-point is fixed at 212, and freezing-point at 32, so that when anything is at 0 degrees Fahrenheit it is 32 degrees below freezing-point. This is called the Fahrenheit thermometer because its inventor, in 1714, was Gabriel Fahrenheit, a scientist born in Danzig.

Men of science prefer to use another type of thermometer, generally called the Centigrade thermometer, because its tube is divided into 100 degrees. "Centigrade" means "a hundred steps." It is sometimes called the Celsius thermometer, because it was invented in 1742 by a Swedish scientist named Anders Celsius. In this thermometer freezing-point is 0 degrees, and boiling-point 100 degrees.

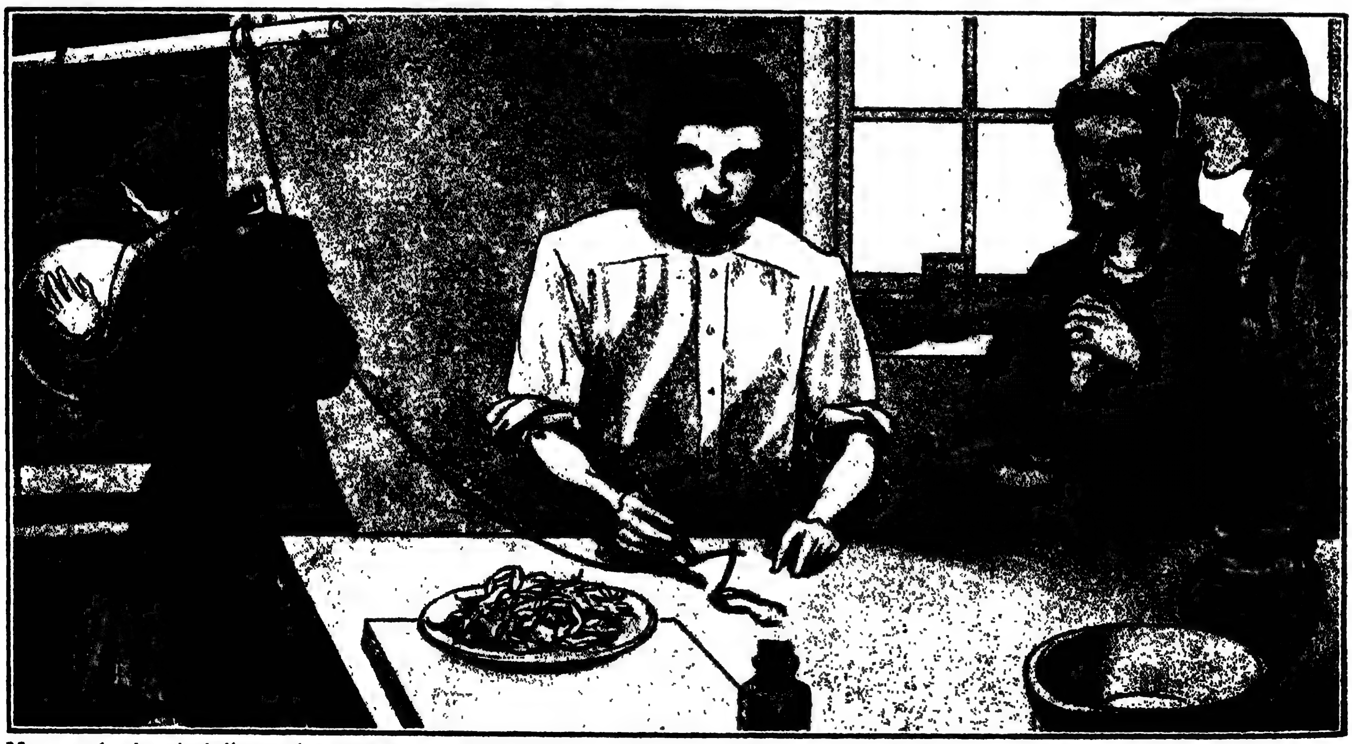
There is still another thermometer used a good deal on the Continent, called the Réaumur thermometer after its inventor, the French scientist René Réaumur. Here there are 80 degrees, freezing-point being 0 degrees and boiling-point 80.



The three thermometers with their boiling and freezing points and corresponding temperatures on the Centigrade and the Réaumur when the Fahrenheit is 80 degrees

EARLY EXPERIMENTS WITH ELECTRICITY

Most of our electrical power is obtained by frictional electricity generated by a dynamo. The origin of the dynamo was simple, and this picture shows the first electrical machine made in 1672 by Otto von Guericke, the man who invented the air pump. He made a globe of sulphur which he rotated rapidly by means of a large wheel. When a man's hands were pressed against the globe, as shown on the right, the friction generated electricity. This he collected by suspending, over the sulphur globe, a long metal cylinder on silken cords. with a chain descending to the globe. A glass bottle of water was electrified by suspending in the liquid a chain from the electrified rod



Many early electrical discoveries were the result of chance. This picture shows one made in the house of Galvani, lecturer on anatomy in Bologna University. While his wife was preparing frogs for soup one of Galvani's assistants was working an electrical machine. The young man touched a frog's leg with a knife and the leg began to move as if it were alive. Madame Galvani told her husband, and he repeated the experiment with more technical apparatus, and found that whenever the flow of electricity from the machine was brought near the nerve of the frog's leg it moved violently. This led to many discoveries in connection with electricity

WONDERS OF THE SKY

MILLIONS OF UNIVERSES IN DISTANT SPACE

Our knowledge of the marvels of the universe is ever growing, and the giant telescope linked with the camera and the sensitive photographic plate are revealing more and more of the wonders of distant space. Tennyson's words, "Let knowledge grow from more to more," were never truer than to-day, and as our knowledge increases the poet's prayer asking that "more of reverence in us dwell" must surely be fulfilled. In these pages we read about vast universes in hitherto unfathomable distances which have only become known to us in the last year or so by mean of wonderful developments in telescopic photography

THE astounding growth of knowledge since the end of the 19th century has compelled us again and again to change ideas that were supposed to be fixed. The infinitely small and the infinitely great have become infinitely smaller and infinitely greater with the advance in scientific research.

That the atom was the smallest particle of matter that could exist was regarded not so long ago as an unalterable fact, a kind of law of the Medes and Persians which altereth not; now we know that so far from being the smallest particle an atom is really a collection of particles, a kind of miniature solar system with a nucleus as its sun, and whirling electrons as the planets circling round.

At the other extreme of the scale we have space and stars expanding to distances which were never dreamed of at the beginning of this century. In other words, the Universe has grown by leaps and bounds and as the power of the telescope increases, so more and more of the realms of space come into view.

A Mysterious Region

What is the Universe? The word itself comes from the Latin and means "all together," or "all taken collectively," and as such it is a good word. But what is All? Centuries ago the Universe meant the world on which man lived. Very little of it was known—just the belt of land surrounding the Mediterranean Sea—and all beyond was the mysterious region extending far into unknown distances.

The world was the universe, and even to-day we are reminded of this by the fact that a history of the world is still called a universal history.

Then men began the study of the heavens and came to the conclusion that those twinkling lights in the sky were other worlds, an idea that was developed rapidly after the invention of the telescope. The word universe was now extended to include not only the world but the Sun, planets, stars and the nebulae.

A faintly luminous band was seen to go across the heavens from horizon to horizon, and as telescopes became more and more powerful this band was found to be made up of millions of stars. The ancients, with their fanciful imagination, had likened it to a stream of milk and had called it "The Milky Way" or "Galaxy" from the Greek word *galaktos*, meaning milk. The Universe had now expanded to include these myraid stars or suns and the other isolated stars of distant space outside the Milky Way.

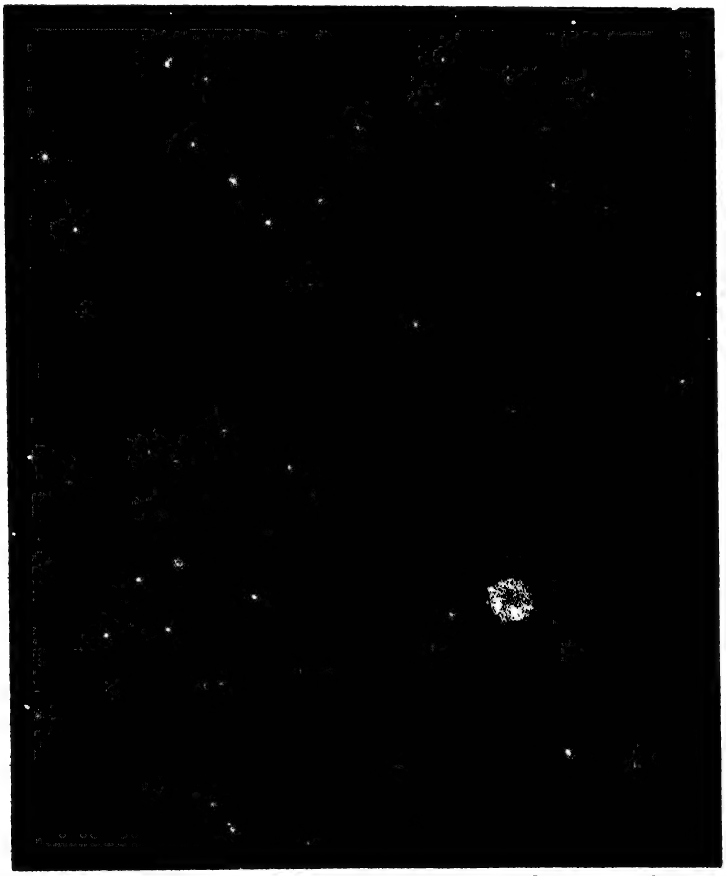
But in recent years an entirely new conception of the Universe has come to men of science as the result of observation through the more powerful telescopes now found in the great observatories of the world, chiefly in America.

Faint patches of light had already been seen in different parts of the sky, one of them at least being recorded by a Persian astronomer, as far back as the tenth century. They were called, because of their hazy appearance, Nebulae, the plural of a Latin word *nebula*, meaning mist or vapour.

Stars Innumerable

Seen through small telescopes they certainly look like white clouds, but as more and more powerful telescopes have been introduced and used in conjunction with cameras and sensitive photographic plates, many of the nebulae have been found to consist of innumerable stars, while others which appear as clouds have stars scattered among them.

It might have been expected that the more powerful the telescope the more of these nebulae would be seen, and such is the case. The number, however, has grown to far greater dimensions than had been conceived. At the present time about two million nebulae have been recorded, but not only has their number grown to this amazing extent, with increased



This remarkable photograph was taken by means of a camera in conjunction with the 100-inch reflector telescope at Mount Wilson Observatory, California. Most of the points of light seen are not stars but nebulae or universes millions of millions of miles in diameter. Each contains either thousands of millions of stars or enough glowing gas and dust to make up such a host of stars. The photograph, published by courtesy of Mount Wilson Observatory, shows only a small part of the heavens in the neighbourhood of the constellation Coma Berenices or Berenice's Hair. In other parts about two million such nebulae can be photographed

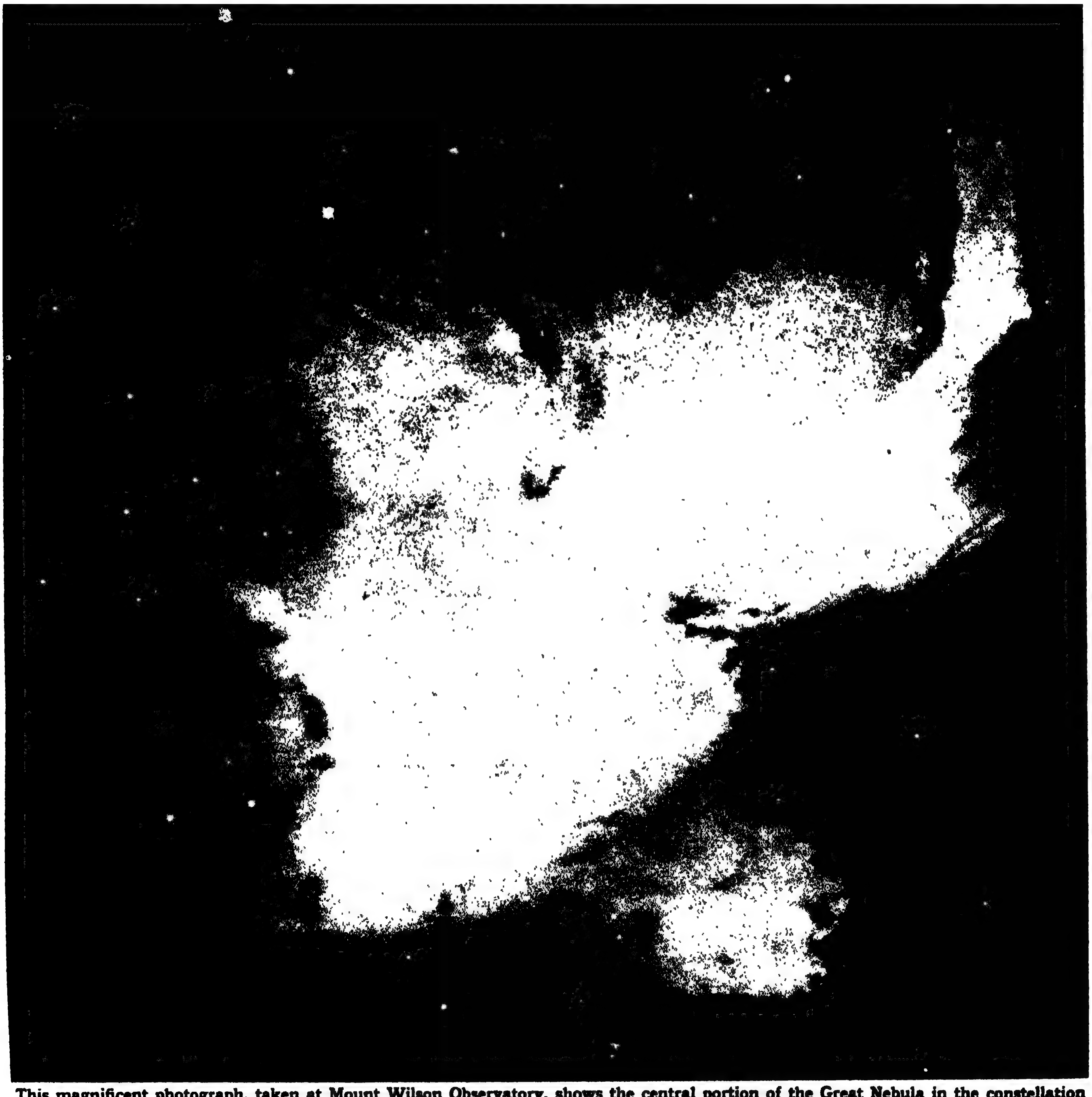
knowledge, their distance from the Earth has been pushed back farther and farther. Some of them, Sir James Jeans, the great English astronomer, tells us, are 140 million light-years away, while Dr. Henry Norris Russell, Director of the Observatory at Princeton University, says some are 250 million light-years distant.

Now a light-year is the distance a ray of light will travel in a year. The speed of light is 186,000 miles per second, and therefore a light-year is 5,876,068,880,000 miles If we write down 1470 with 18 noughts after it we shall then get the number of miles that some of the more distant nebulae are from our Earth.

Of course, these figures are too big to mean much to us, but they do give us some idea of the immensity of space and the inconceivably vast size of the Universe as we know it to-day. Perhaps in years to come men of science will have found out so much more that they will smile at our ideas of the Universe, just as we smile at those of the men of the ancient world.

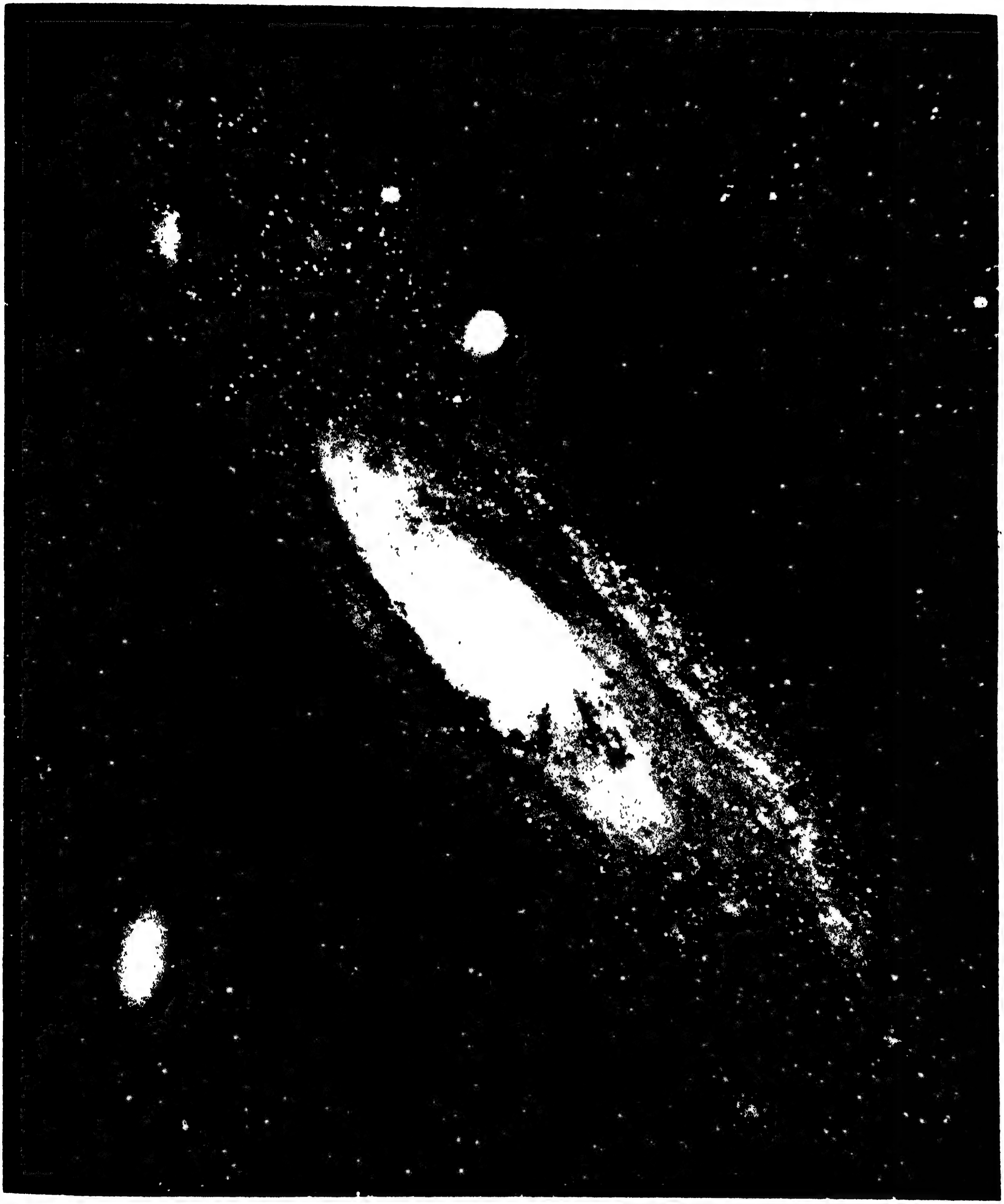
Now let us come back to the nebulae. The latest idea of the astronomers is that many nebulae are not merely huge clouds of shining gas or vast clusters of stars which form part of our Milky Way universe, but are other universes, each a kind of Milky Way in distant space.

The astronomers distinguish various kinds of nebulae, and one kind, like the Great Nebula in the constellation Orion, forms part of our Milky Way universe. There are others of the same kind, all in this universe to which we belong, and they are very irregular in



This magnificent photograph, taken at Mount Wilson Observatory, shows the central portion of the Great Nebula in the constellation of Orion. It consists of clouds of dust and luminous gas stretching across immense areas of space, and is the finest of all the gaseous nebulae which we know. Its size baffles our imagination. It is 25 light-years in diameter, which means that from one side to the other it is nearly 150 million million miles. Our world placed in its midst would be but a grain of sand

A UNIVERSE OF INCREDIBLE SIZE



The Great Nebula in the constellation Andromeda has been known for centuries, for it is visible to the naked eye. But it is only in recent years that its true nature has been discovered. This wonderful object is, Sir James Jeans tells us, another universe like the great Milky Way universe to which our solar system belongs. The Andromeda Nebula is so far away that its light is said to take 900,000 years to reach us, which means that if it were blotted out of existence to-day it would still be seen in the sky from our Earth for 900,000 years more. It contains thousands of millions of stars, and is 50,000 light-years across from one side to the other. As we look at it through a telescope we can, in a moment of time, glance across nearly 300,000 million million miles of space. It is a staggering thought, and we may well be thrilled as we look at this photograph taken at Yerkes Observatory, U.S.A., and realise the distance from one side to the other

shape, something like a drifting mass of steam or smoke.

At one time it was thought that they were great clouds of glowing gas, but now it is believed that they consist not only of luminous gas, but also of huge clouds of dust, called by scientists " cosmic dust," sometimes lighted up by the stars in their midst and sometimes remaining dark so as to blot out the stars behind them. There are big dark patches in the skies which were formerly thought to be empty spaces, but are now believed to be caused by these dark nebulae.

Wisp-like Nebulae

Sometimes the irregular nebulae, instead of being like bunched clouds, are wisp-like in form. One such nebula is seen in the constellation Cygnus. This is believed by some astronomers to be really the edge of a great dark nebula lighted up by the stars, very much as the edge of a black cloud in our sky can be lighted up by the Sun shining through or upon it.

These irregular nebulae, however, are quite different from the other class of nebulae away in space beyond the Milky Way. Those are more or less regular in form. Some are like globes, some like rings, some like discs ; others have the shape of a dumb-bell or a spiral, and these regular shaped nebulae are now thought to be self-contained universes similar to our Milky Way universe, though smaller, and their different forms are believed to be due to the fact that they are at different stages of their history.

Some are young like babies or children, others are in the youth stage ; while others are adults, some middle-aged and others old. It is these nebulae, which Sir James Jeans calls Star-cities, that are so inconceivably distant. The nearest of them is a nebula in the constellation Triangulum, and this is 850,000 light-years distant. The second nearest is the Great Nebula in Andromeda which is 900,000 light-years distant.

Not many of the nebulae can be seen with the human eye through the telescope, but they are recorded on sensitive photographic plates. At some points in the heavens, indeed, the majority of the patches that appear on the plates are nebulae and not stars. One such cluster of nebulae occurs in the direction of the constellation Coma Berenices, or Berenice's Hair.

The largest of all the universes that occupy space is believed to be our Milky Way system, and Sir James Jeans compares it to London, the largest city in the world. So big is it that some astronomers think that it consists of a number of overlapping Star-cities.

London and the Star-cities

" If London represents the Galactic system in size," says Sir James, " Cambridge and Oxford just about represent the sizes of the two nearest Star-cities. And the comparison holds good in respect of the number of inhabitants as well as of the arrangement in space ; London has roughly 100 times as many inhabitants as Cambridge or Oxford, and our Star-city contains something like 100 times as many stars as either of its two nearest neighbours."

Another astronomer, Dr. Shapley, says : " If the nebulae are island universes, the Milky Way is a continent."

The Milky Way system to which we belong is like an immense flattened lens in shape, its greatest diameter being 300,000 light-years or, in miles, nearly equal to 1,763 followed by sixteen noughts. Its thickness is 100,000 light-years or, in miles, nearly 59 followed by seventeen noughts. We read some further facts about these nebulae, Star-cities or Island-universes, as they are called, in other parts of this book.

Millions of Glowing Suns

But what a stupendous fact it is to think of the universe or the " all together " consisting not only of the Milky Way with its millions of glowing suns, but of millions of other similar universes scattered throughout a space so vast as to be quite inconceivable.

The powerful telescopes of recent years have revealed these facts to us, but scarcely less wonderful is it that the mind of a great philosopher who lived 200 years ago, Immanuel Kant, the son of a saddler of Scottish origin, conceived this amazing idea of the universe.

" If," he wrote in 1755, " the grandeur of a planetary world in which the Earth as a grain of sand is scarcely perceived, fills the understanding with wonder, with what astonishment are we transported when we behold the infinite multitude of worlds and systems which fill the extension of the Milky Way ! But how is this astonishment increased when we become aware of the fact that all these immense orders of Star-worlds again form but one of a number whose termination we do not know, and which perhaps like the former, is a system inconceivably vast —and yet again but one member in a new combination of members ! "

THE BRITISH ISLES AS SEEN FROM THE SUN

As we know, owing to the tilt of the Earth the Sun's rays do not always strike a particular region at the same angle The warmth or otherwise of a country depends upon the directness of the Sun's rays, and as we can see on pages 182 and 183, countries which are on or near the Equator receive the Sun's rays more directly than countries north or south.

Britain seen from the Sun in summer

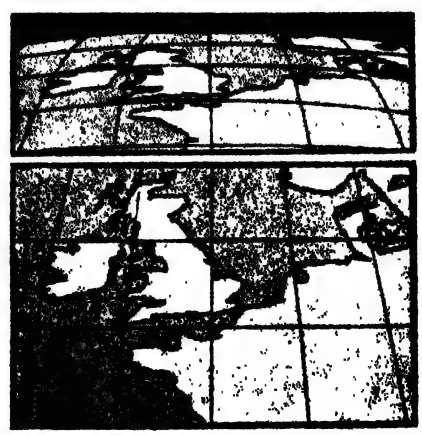
Further, the heat depends less upon our nearness to the Sun than upon the direction of the rays That is why although in winter we are some three million miles nearer the Sun than we are in summer, the heat we receive is much less than it is in summer. The same amount of sunshine when the rays come slantingly has to cover a greater area of the Earth's surface than when they come directly.

The maps given here, which have been drawn in perspective, show what that part of Europe which contains the British Isles would look like if it could be seen from the Sun at different seasons of the year.

In the first map we are looking at the British Isles from the Sun at noon on Midsummer Day (Greenwich time) It is obvious that the rays of light and heat passing from the Sun strike fairly directly upon this part of the Earth's surface.

Now let us look at the other two maps. The top one shows what this same area would look like if it could be seen by a spectator on the Sun at noon in midwinter. We can see that now the Sun's rays must be striking this area very slantingly, and consequently much less heat and light are received than at midsummer.

The lower map shows the British Isles and the north-west part of Europe at noon on a spring or autumn day. Here, of course, the Sun's rays strike much more directly than at midwinter, but less so than at midsummer.



A Sun view of Britain in winter and spring

SOME STRANGE FACTS ABOUT FRICTION

Why do we oil our bicycles? And how is it that by putting on the brake we can stop a motor-car or train? There would seem to be little or no connection between these two things, and yet they are both dependent upon the same principle. It is to get rid of friction that we oil the axle of the bicycle wheel, and it is to cause friction that we put on the brake of the motor-car or railway engine. Friction, indeed, is of great importance in machinery. Sometimes the engineer strives with might and main to get rid of friction, and at other times he uses it to further his purpose. Here are some interesting facts about friction, and how it helps and hinders us

FRICTION is a fact that all engineers and those who use machinery have to take into consideration. It is indeed one of the most important facts in our lives, and strangely enough it is both a friend and an enemy.

It works for us in all sorts of ways. If it were not for friction we could not walk or hold a pencil or get up when we had fallen down, nor when a train or a motor-car or a cart had been started could it be stopped, except by running into some obstacle heavier than itself, such as a wall or hill.

A Task for the Engineer

On the other hand, engineers spend a great deal of time and money in trying to overcome friction and do away with it as much as possible. The more nearly they can abolish friction the more efficiently do their machines work. If men could get rid of friction altogether they might then make a perpetual motion machine, that is, a machine that once started would go on for ever without stopping or wearing out.

What exactly is friction? Well, it is described by the dictionary as "the resistance which a moving body meets with from the surface on which it moves," and that is a very good definition.

Some surfaces can be polished very highly, as in the case of a well-burnished metal surface or a sheet of glass. But no surface is really smooth in the sense that it has no minute projections jutting out from it. We see these clearly enough in a piece of rough stone or on the surface of a biscuit, for example. But we need a very powerful microscope to see the projections on a piece of brightly polished steel or a sheet of plate glass. Nevertheless they are there all the same, and the amount of friction or resistance when we move one surface over the other depends upon the smoothness, that is, the degree to which the projections have been removed.

The highly polished surfaces of a shaft and bearing magnified to show the inequalities which lead to friction

The diagram on this page, which shows two surfaces in contact, represents how the projections on one interlock with the indentations on the other, and thus hinder the progress of movement.

It is friction that prevents a machine from doing the full amount of work it should do, that is, giving out as much energy as is put into it. There is, because of friction, no perfect machine.

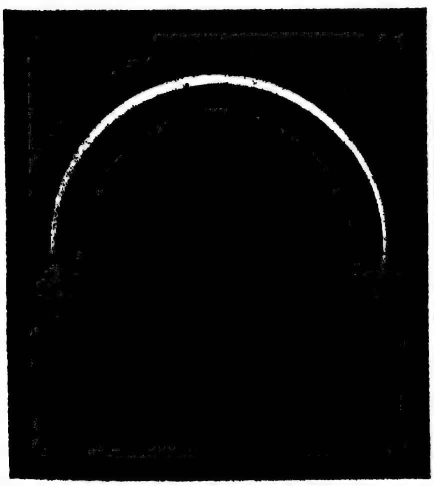
Friction causes things eventually to wear out, whether they be machines or bicycle tires or clothes or chairs or carpets or paving stones or black-lead pencil points. The interlocking of the minute projections as one surface passes over another causes some of these to be rubbed off and that, of course, is wear.

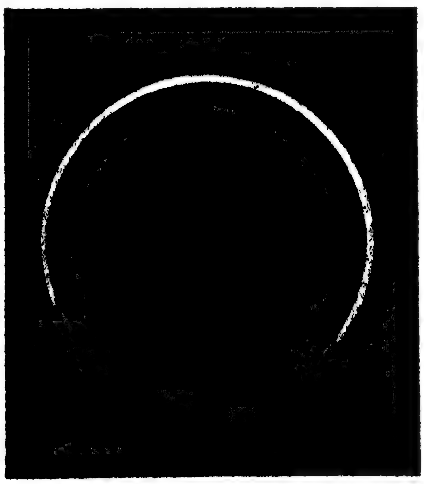
Some Ingenious Devices

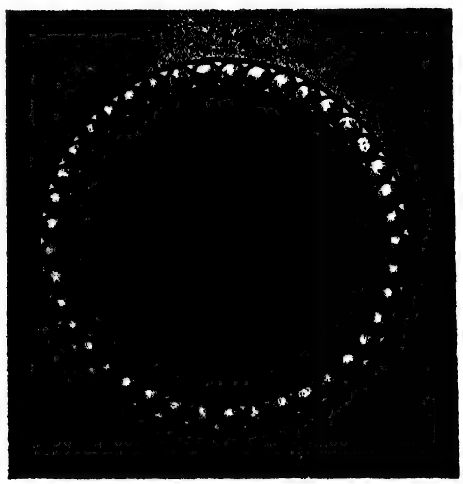
It will be seen, therefore, how important it is to the engineer to reduce friction as far as possible, in such places as the bearings in which axles turn, and so on. If a shaft or axle turns in a metal bearing, rubbing against it all the time, it is not long before both axle and bearing are worn, and have to be renewed.

To get over this difficulty in machinery various ingenious devices have been invented. For instance, we use oil to lubricate machinery, and the effect is that the axle or shaft, instead of turning on the bearing and wearing both out, now moves round in a film of oil, which spreads all round.

A liquid is almost incompressible, that is, under pressure it cannot be squeezed into a smaller space, and so when the bearing is kept oiled there is







On the left is a shaft turning in a bearing without lubrication. There is much friction especially at the bottom on the side towards which the shaft is rotating. In the centre we see how by lubrication a film of oil surrounds the shaft thus greatly reducing friction. The right-hand picture makes clear how ball-bearings minimise friction by reducing the points of contact

a thin coating of the fluid between the shaft and the bearing. This is much smoother for the axle to move in, and so the friction is greatly reduced.

Another way of reducing friction is to use ball bearings, as we do in the case of our bicycle wheels. But why, we may ask, should ball bearings reduce the friction? Well, there are two reasons. In the first place, as we can see if we look at the picture on page 201, the points of contact between a shaft or axle and a set of ball bearings are far fewer than between a shaft and a bearing without the balls. The surface that sets up friction is therefore of much less area, and so there is less friction.

Rolling and Sliding Friction

But there is a second reason why ball bearings are so useful. There are two kinds of friction, one known as sliding friction, which is due to a body being pushed or slid over another, and rolling friction, which occurs when one body rolls over another, as in the case of a wheel travelling along a road. Rolling friction is much less than sliding friction, as we can prove for ourselves by a very simple experiment.

Fill a wooden box with stones and try to drag it across the ground. You have to exert a great deal of energy to do so. Now place the box of stones on a framework with wheels, or put it on rollers and roll it along, and you will find that much less energy is needed. That is why the wheel is one of the greatest inventions that man has ever made, and it is why ball bearings and roller bearings in machinery are of such enormous advantage, and help the machine to give out much more power than it would without their aid.

How much greater sliding friction is than rolling friction we can prove by another simple experiment. Take any wheeled vehicle, such as a toy cart or a perambulator, and see how much

How oiling the mangle wheels reduces friction by separating the wheels with a film of slippery oil

more difficult it is to pull it over the ground sideways than to roll it to and fro on the wheels. In the former case we experience sliding friction, and in the other case rolling friction

But now we come to a strange paradox in connection with friction. Seeing that the engineer spends so much time and money and ingenuity in overcoming friction and reducing it to a minimum, we might think that if he could get rid of it altogether his machines would work perfectly But the strange thing is that they would not, for while friction hinders us a great deal, it also helps us

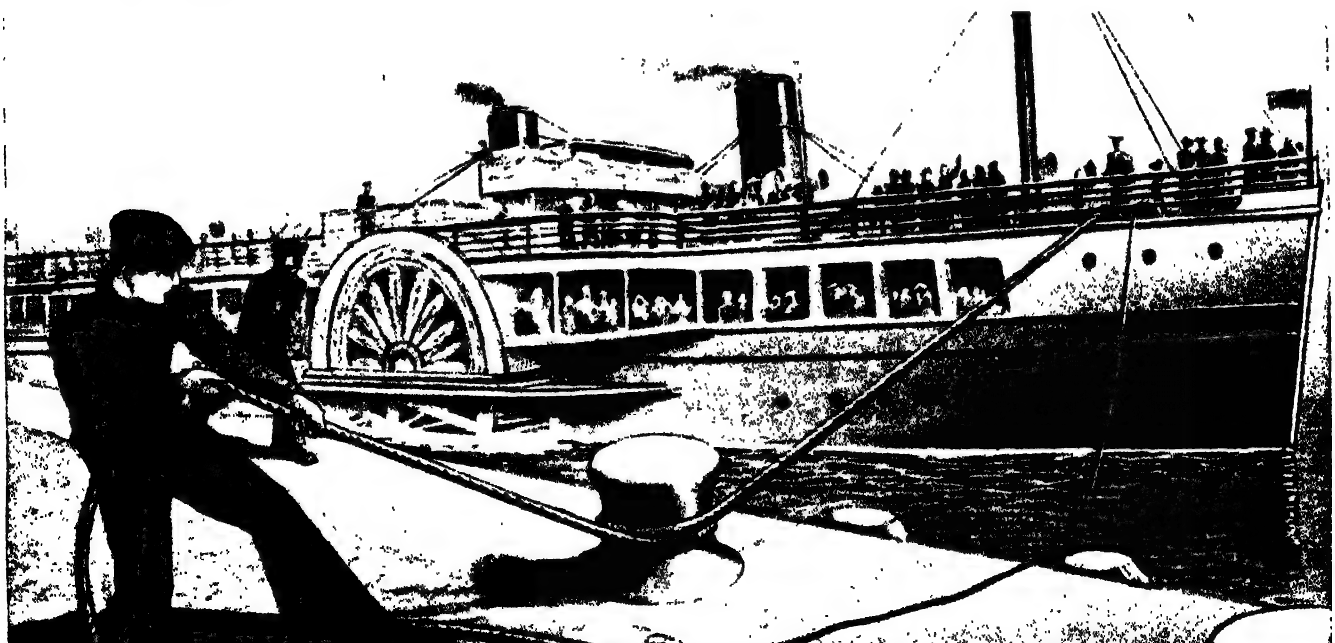
Let us take one or two examples On a railway line the friction between the wheels and the rails is reduced to a minimum. But supposing it were abolished altogether, the train would stand still. It could not start at all, for there must be a certain amount of friction in order that the wheels may grip the rails and be enabled to carry the train forward. If there were no friction the wheels would go round and round and the train remain stationary.

Where Friction is Needed

But if by any means the train could be set going, if there were no friction it could never stop without a collision, for it is by using the friction of the brakes on the driving wheels that, after the steam is cut off, the train can be brought to a standstill. The small amount of friction that exists between the wheels and the rails also helps in pulling up the train.

It is because of friction that pieces of wood can be nailed together. Were there no friction between the nail and the wood the nail would turn round and round and slide out quite easily It is friction that gives the grip Without friction, unless a surface were as level as a billiard table everything would slide off

If there were no friction it would be impossible to drive machinery by belts and pulleys, for there would be no grip between the belt and the pulley, and so the driving wheel would move round and round in the belt without turning it. Without friction, of course, the motor-car could not move along the



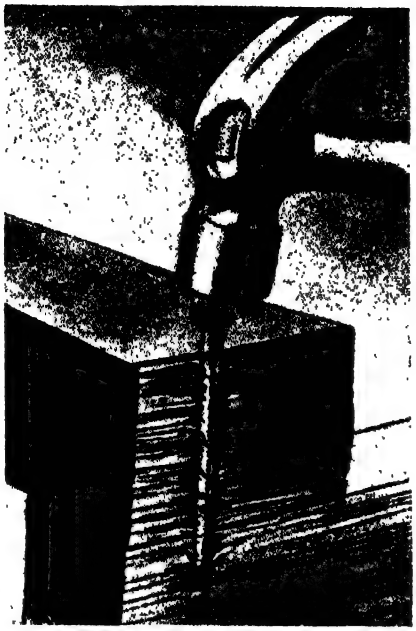
One way in which friction is of great assistance. The man is able to hold the ship to the quay because of the enormous friction between the rope and the bitt or post round which it is twisted

road, but even supposing it had been set going before friction was abolished, we should now be unable to steer it, for when we tried to grip the steering wheel our hands would slip right round

If Friction Failed

Nobody could pull anything along by grasping a rope, for the rope would slide through their fingers. Sometimes on a railway, when it has been raining, the rails become what is described as "greasy," and when a train tries to start the engine wheels turn round and round and cannot grip the rails, because friction has been so greatly reduced. This is a slight example of what might happen if in certain cases friction were reduced too much.

Various methods are adopted of reducing friction. When, for instance, a new vessel is to be launched the slips down which it is to slide are heavily greased or soaped so as to reduce the friction between the ship and the timber. Graphite or powdered blacklead is sometimes used for lubricating. In this case and in the case of the soap or fat the friction is reduced by the lubricating substance filling up the inequalities of the rubbing surfaces and making them very much smoother than they would otherwise be



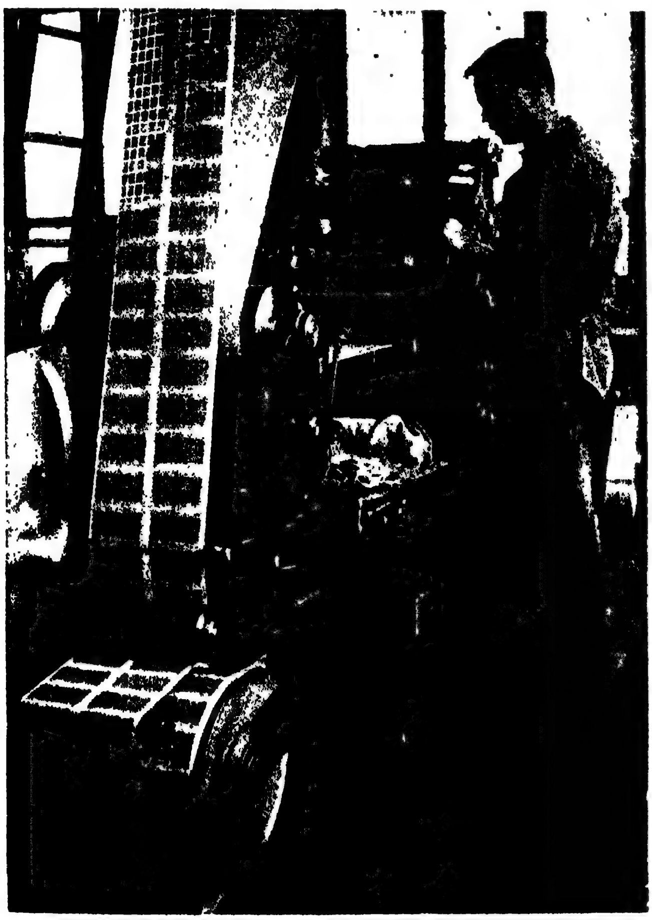
Friction holds the nail in the wood

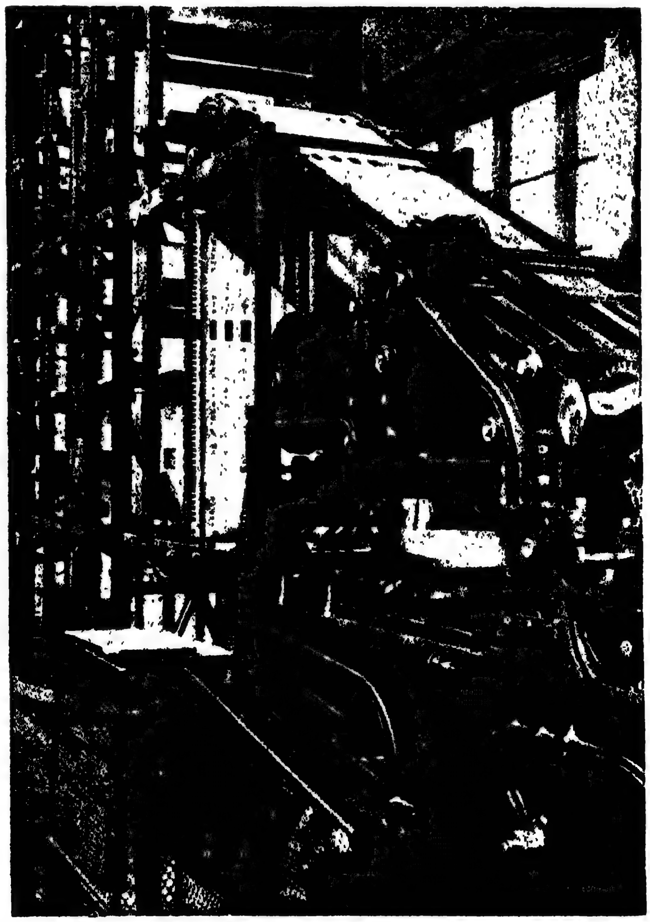
One other fact about friction must be remembered, and that is that when the friction is between a solid body and a fluid the friction increases with the speed. This is the case with a vessel travelling through the water, and with a body travelling through the air The friction of the air is very small with a slowly moving train, but it becomes a very great factor when a train is travelling at high speed

Friction of Air and Water

A liner with a total weight of 38,000 tons can be driven through the sea at a speed of 17 knots by engines of 14,000 horse-power But a liner weighing 26,000 tons needs engines of 40,000 horse-power to drive it at a speed of 24 knots. The friction of the air, too, is very great in the case of a fast travelling aeroplane or airship, and that is why aircraft are always designed so that the form will offer the least possible resistance to the air.

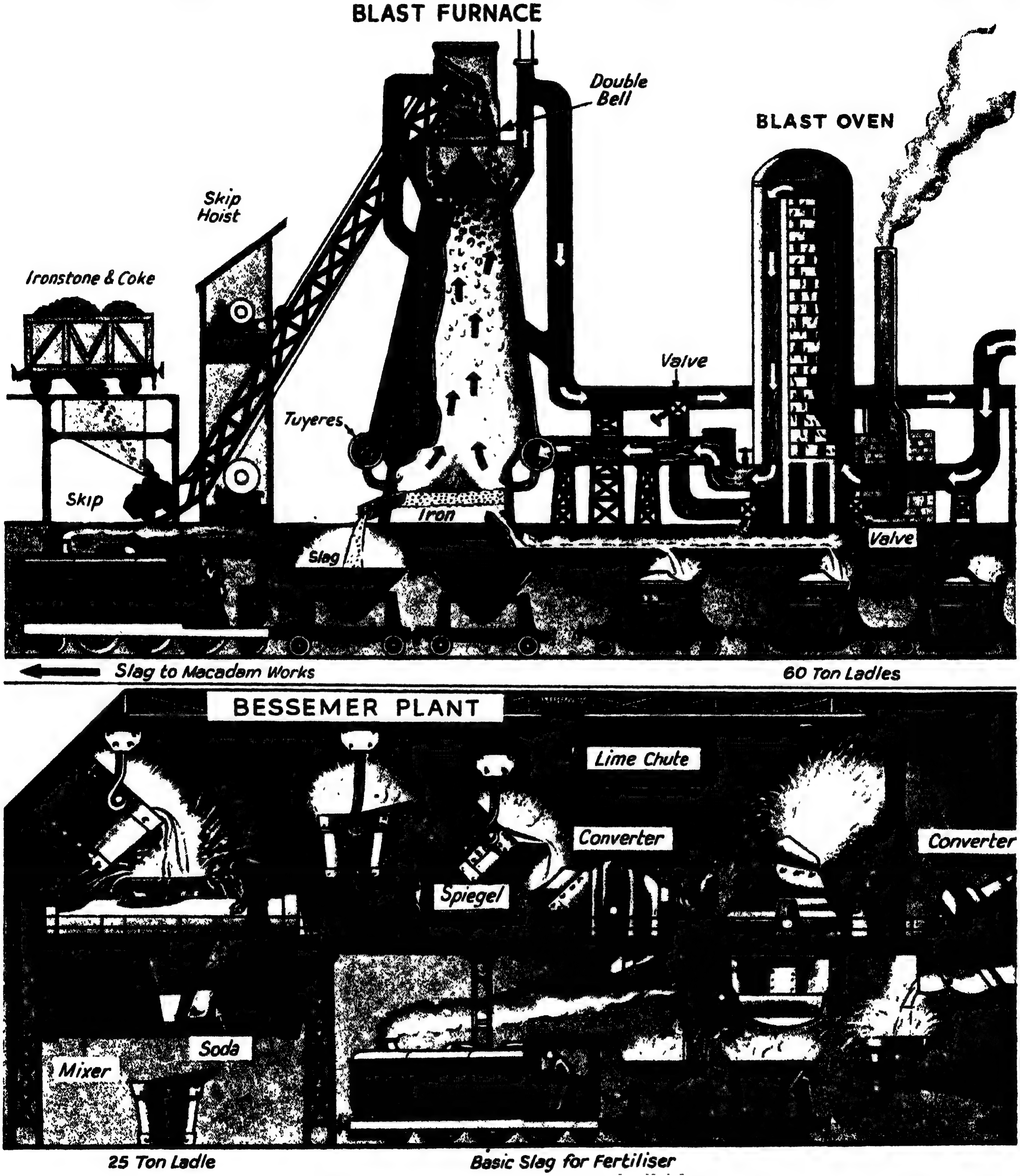
MACHINES THAT PRINT & GUM 10,000,000 STAMPS A DAY





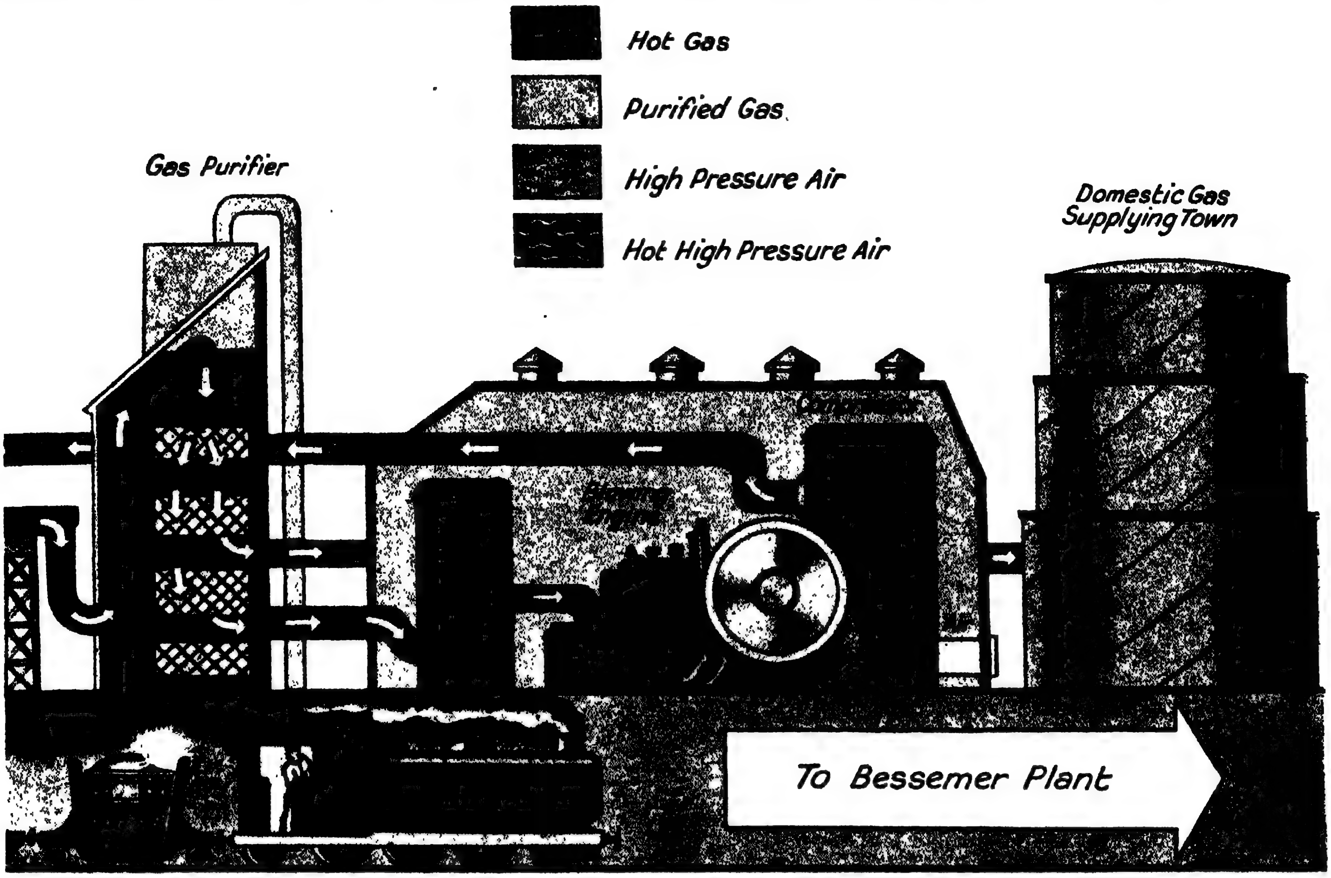
What sort of a machine is it that prints, perforates and gums the millions of postage stamps that are used in all civilised countries every day of the year? Well, here we see on the left a machine that prints and perforates ten million stamps a day. A roll of paper is put in at one end and comes out at the other end printed and perforated. Then the rolls pass to the gumming machine, seen on the right, where they receive a layer of gum on one side, and afterwards the paper is passed through a special machine which dries the gum so that the stamps are then ready for cutting up into sheets for sale at the post office

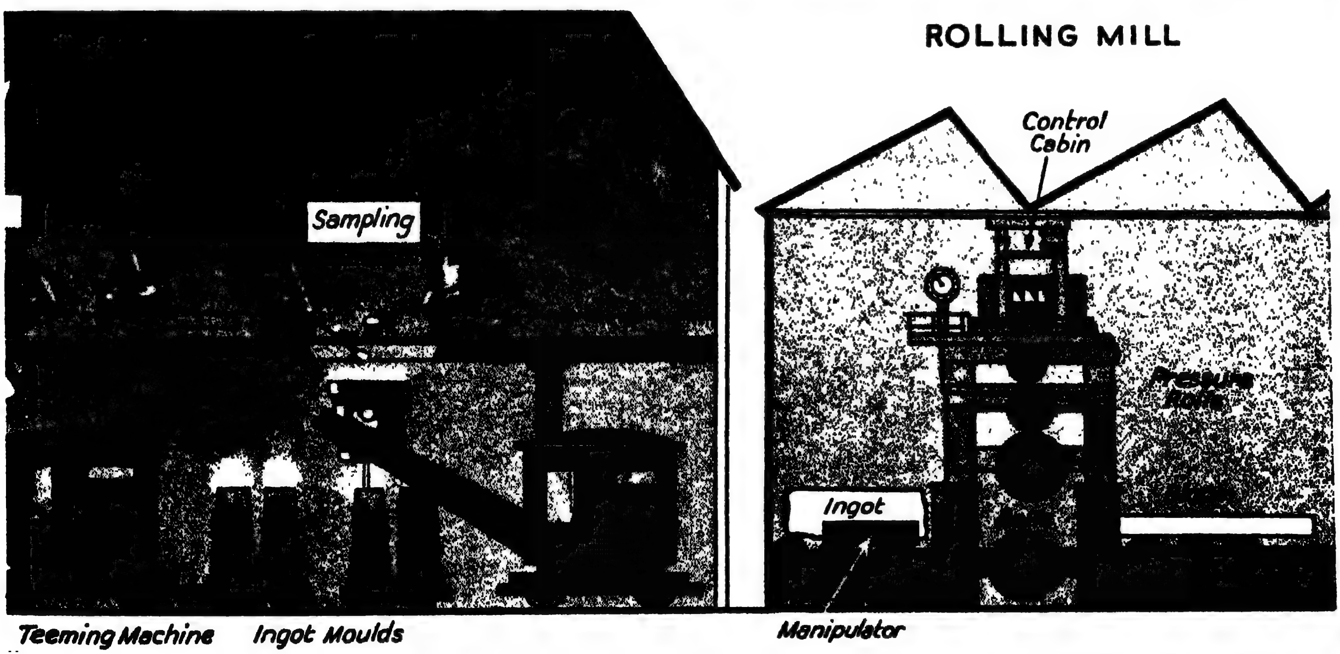
HOW A FOUNDRY MELTS IRON FROM



In this double-page picture we see in detail the whole process of obtaining iron from its ore and converting the iron into steel. Iron ore, limestone and coke are fed from trucks carried on a skip hoist into the top of a blast furnace. Intense heat is generated in the furnace by blowing on to the glowing coke a blast of hot air through openings called tuyères. The hot gases which escape from the coke in the furnace are carried through pipes to a purifier. Some of the purified gas is used to drive the blowing engine which compresses the air for the furnace blast ; the remainder of the gas is stored in a gasometer and sold for domestic consumption. In the blast furnace the iron is melted out of the ore and the molten iron is then drawn off from the bottom of the furnace and poured into ladles mounted on bogie trucks and hauled by a locomotive to the Bessemer plant. The slag or refuse matter from the ore is also drawn off from the furnace, but through an outlet higher than that from which the iron flows ; this is because the slag is lighter than the molten iron and floats on top. The slag is hauled away and used for road-making and similar purposes. In the Bessemer plant the ladles of molten

ITS ORE AND CONVERTS IT INTO STEEL





iron are emptied into a container for mixing with soda. The iron, still molten, is next poured into a converter and has added to it lime and spiegel. The converter is heated by glowing coke and when full is turned upright and a jet of high-pressure cold air is blown into the bottom. The force of the air causes a blast of flame to issue from the top of the converter and this carries with it unwanted materials, so converting the iron into steel. The converter is then mechanically swung over and the molten steel poured into a ladle carried on a vehicle called a Teeming machine. Samples of the steel are scooped out of the ladle to test its quality, and if the steel is up to standard it is poured into the ingot moulds. The ingot moulds are hauled on trucks to the rolling-mill. There cranes place the ingots on to a series of rollers and guard rails called a manipulator which feeds them between power-driven rollers. The rollers can be so adjusted from a control cabin that their pressure is increased or decreased, and this governs the thickness of the ingot passing between them. Emerging from the rolling-mill, the ingots of steel are called blooms, and are ready for casting or machining into any shape

THE INSIDE OF AN ACTIVE VOLCANO

The Earth on which we live has a very hot interior. It was once a ball of fire, but the outside has cooled down into a hard crust, though underneath rocks are still in a molten state. From time to time there are underground explosions, and it is fortunate for us who live on the outside of the crust that the Earth has all round it a number of safety valves where the hot gases can escape, otherwise great areas of the Earth's crust might be blown away. These safety valves we call volcanoes, and here we see the inside of a volcano, with its reservoir of molten rock, or lava. We are not sure what causes the periodic explosions underground, though we know that in many cases they are due to sea water trickling through cracks in the Earth's crust and reaching a bed of molten rock, when it is instantly turned into steam and hurls up masses of lava with ashes, hot gases and steam. The conical mountain that we call a volcano is really only part of it, as we see above. The volcano includes those parts that are out of sight, deep down in the Earth's crust

THE EARTH'S MANY SAFETY VALVES

Volcanoes are the safety valves of the Earth. Beneath the Earth's crust at varying depths lie molten rocks, and sometimes explosions occur deep down which would blow away a portion of the crust were it not for the volcanic vents through which the gas and lava can escape. The true nature of volcanoes is explained in these pages and we are able to see how it is that eruptions occur

SCATTERED about the world there are between three and four hundred mountains that from time to time spurt out fire, often overwhelming the whole district round for many miles with devastation.

These mountains have from ancient times been called volcanoes. The name was originally given to Mount Etna and to Stromboli in the Lipari Islands, because they were regarded as being the locality where the god Vulcan had his fires and forge. Then as other volcanoes were discovered, the name was applied also to them, and now any mountain that throws out fire, or is known to have done so in the past, is called a volcano.

Volcanoes, however, are divided into three classes. First there are active volcanoes, those which nowadays become active more or less frequently, such volcanoes, for instance, as Vesuvius, Etna, Stromboli, and Cotopaxi in the Andes of Ecuador, the tallest active volcano in the whole world.

Then there are dormant volcanoes, the word dormant meaning sleeping, and this name is applied to those which erupt only occasionally. Vesuvius, for example, is a type of volcano which is dormant from time to time.

Extinct Volcanoes in Britain

Finally, there are what are known as extinct volcanoes, those from which no eruption has been recorded during the history of man. Snowdon and various other mountains in Great Britain are extinct volcanoes.

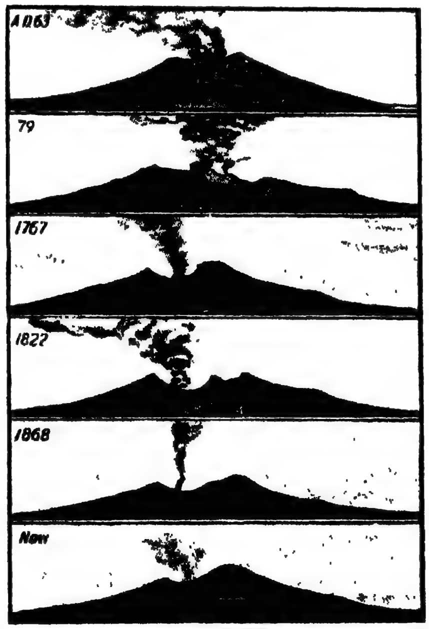
The volcanoes which interest us, however, are those which still have eruptions more or less frequently. There is only one such on the continent of Europe, and that is Vesuvius.

We all know how in the year A.D. 79, after it had been dormant for many years, loud explosions were heard inside the earth and a strange cloud appeared over the summit of the mountain. Then came the terrible eruption which buried Pompeii and Herculaneum in ashes, and destroyed many people. Since that time Vesuvius has had many eruptions.

But although there is only this one active volcano on the mainland of Europe, there are several on the islands lying off the coast. The most notable is, of course, Mount Etna in Sicily. It is two miles high, over a hundred miles in circumference at the base, and in addition to the giant cone which was known to the Romans as the Forge of Vulcan, there are about 200 smaller cones on its slopes.

Then there is Stromboli in the Lipari Islands, an irregular cone rising from the floor of the Mediterranean to a height of over a mile, one half being above the level of the sea. For the last two thousand years this volcano has been active, though not dangerously so. It throws out clouds of steam and showers of stones, and at night the cloud which hangs over it is illuminated with flashes of light, so that Stromboli has come to be known to sailors as the Lighthouse of the Mediterranean.

It is also useful to sailors as providing an automatic storm warning, for it becomes more active when the pressure of the atmosphere is low and gales are to be expected, while, on the other hand, when the barometer rises Stromboli's eruptions become far less violent.



Some of the changes that have taken place in the shape of Vesuvius during the past nineteen centuries

There are also a number of volcanoes in Iceland of which the most important are Hecla and Skaptar Jokul. Sometimes Hecla has remained active for six years, and once a huge explosion blew off its top so that it lost 500 feet of its height.

It was Skaptar Jokul, however, that provided the mightiest eruption that has ever occurred on the earth in the history of man. In 1783 a flow of lava started that continued for two years and covered a thousand square miles of the island. There were two streams of lava flowing in opposite directions, one 40 miles long and the other 50, and it is said that in the first 25 days the volcano poured out more lava than Vesuvius and Etna together have done in all their eruptions during thirty centuries.

The total amount poured out during this eruption of Skaptar Jokul is estimated at several thousands of millions of tons, a quantity sufficient to build up a mountain as big as Mont Blanc.

So much for the volcanoes of Europe. The world's active volcanoes are generally found where the earth's crust is weakest, that is where it has wrinkled into mountain ranges, especially near the sea coast. The majority of the world's volcanoes are found in one of two belts. The greater is that which surrounds the Pacific Ocean from Tierra del Fuego, all up the Western coast of America, across the Aleutian Islands, through Japan and the Philippine Islands, the Dutch East Indies, the Australasian Islands and down to New Zealand. The other belt, which is not such a regular one, goes across the earth from Hawaii, through Mexico and the West Indies, and the Mediterranean region to the East Indies. There are a few other volcanoes outside these areas, but most are found in these two belts.

What a Volcano Really is

What is a volcano? Most people think it is the pyramid-shaped mountain that we see as in Vesuvius or Etna, but this is only the cone. A volcano is really an opening in the earth's crust, through which lava or molten rock and other fiery materials are ejected.

Much of this material becomes piled up round the opening and thus forms the cone, its steepness depending on the kind of material that is thrown out, coarse or fine, liquid or solid. In the top of the cone there is generally a cup-shaped depression, and this is called the crater. It is well that we should know the right names for things.

It must be noted that volcanoes are most abundant in regions where earthquakes are frequent, and it is almost certain that both have the same kind of origin. Often an earthquake precedes a volcanic eruption. In all cases,

there are subterranean rumblings before the eruption. Scientists are not all agreed as to exactly what causes the eruption, but there is no doubt that it is due to the internal heat of the Earth. The pressure at great depths is enormous, and in some way a gas explosion occurs and something has to give way.

Volcanoes are really safety valves for the Earth. When the explosion takes place the great volume of gas suddenly released must escape somewhere, and it does this through a weak spot, either the main crater of the volcano or through fissures in the sides. An eruption is really a volcano clearing its throat.

If, during a period in which it has been dormant, the crater has become filled up with falling blocks of rock, then, when the explosion occurs, these are hurled out, often to a great height. The molten rock is often mixed with water, and it is sometimes the sudden formation of steam that causes the eruption.

Where the volcano is near the sea it may be due to sea water trickling through cracks in the Earth's crust, and at last reaching a basin of molten rock. This is no doubt what happened at Krakatoa, a small island in the middle of the Strait of Sunda in the East Indies.

On August 27th, 1883, there occurred there the most terrific explosion that has ever been known. A great column of dust and vapour was shot up twenty miles into the air. The roar was heard 3,000 miles away, and was noticed over a thirteenth of the Earth's surface.

This is Stromboli, the famous volcano which is often called the Lighthouse of the Mediterranean. It rises to a height of over 3,000 feet, and is always active, although sometimes more so than at other times. The name "volcano," after Vulcan, the god of fire, was first given in ancient times to Stromboli and Etna

Windows were broken and walls cracked in Batavia, a hundred miles away, two-thirds of the island were blown to pieces, the disturbance produced a sea wave one hundred feet high which rushed round the neighbouring countries and washed away more than 36,000 people, and the fine dust was carried right round the world.

When a violent eruption occurs the top of the cone is often blown from a volcano so that its shape is changed. Vesuvius has varied greatly in appearance owing to this cause during the centuries. During the great eruption of 1906 the top of the cone was blown away, so that the mountain became several hundred feet shorter.

The molten rock that pours down the mountain side solidifies into a hard substance, and the froth or foam on top when it hardens becomes pumice stone so light that it will float in water, owing to the many air bubbles inside. Pumice stone is also formed in another way. When the lava is thrown high into the air and becomes solid as it falls to the earth, it often becomes filled with bubbles by expanding gas so as to become frothy or spongy.

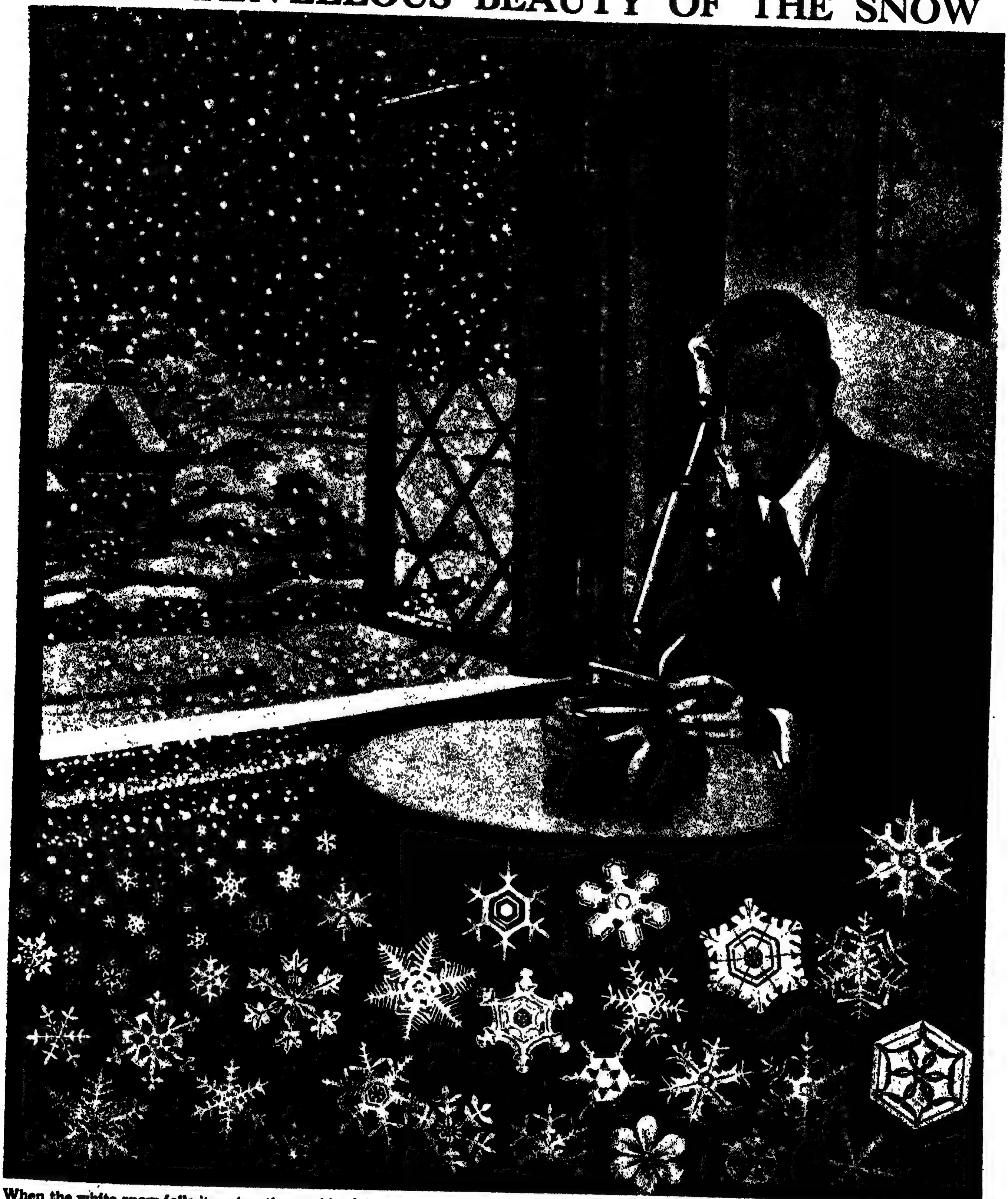
When lava gets weathered into fine dust it forms an excellent soil for growing crops. Molten lava often pours down a mountain at 50 miles an hour.

A very popular idea is that a volcano in eruption pours out great flames of fire, but this very rarely happens. What appears to be flame is really the reflection on the cloud of vapour of the fiery molten rock in the crater.

THE BIRTH OF THE ICEBERGS IN THE POLAR SEAS

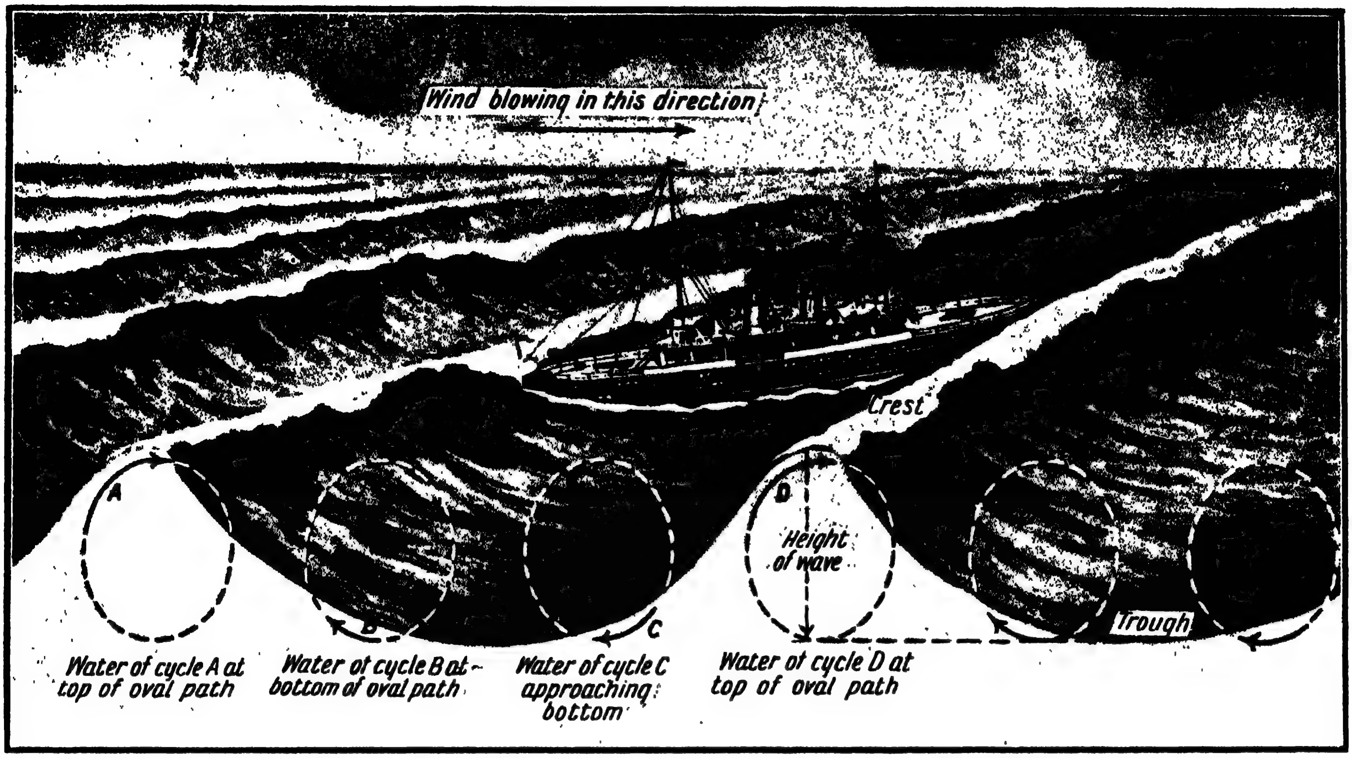
Covering Greenland and other land regions of the Arctic north are fields of ice sometimes nearly a mile thick. These ice-fields are like huge glaciers, and move slowly towards the sea. When at last the ice reaches the sea the sheet cracks and huge fragments break off and float away south as icebergs. When they reach the warmer water and the more powerful sunshine they gradually melt and become merged in the ocean. Of course, while they are floating about in the sea, they are a great menace to shipping, especially when they cross the Atlantic trade routes. It is believed to have been collision with an iceberg that led to the sinking of the Titanic. In this picture we see a glacier arriving at the sea, where the buoyancy of the water shears off the icebergs which float away south. In some parts the flow towards the sea of the ice in the form of a glacier or ice-field is as much as forty or fifty feet a day. Vast as are the glaciers and ice-fields in the Arctic, they are exceeded by even more stupendous examples in the Antarctic, where the ice is said to be several miles thick

THE MARVELLOUS BEAUTY OF THE SNOW

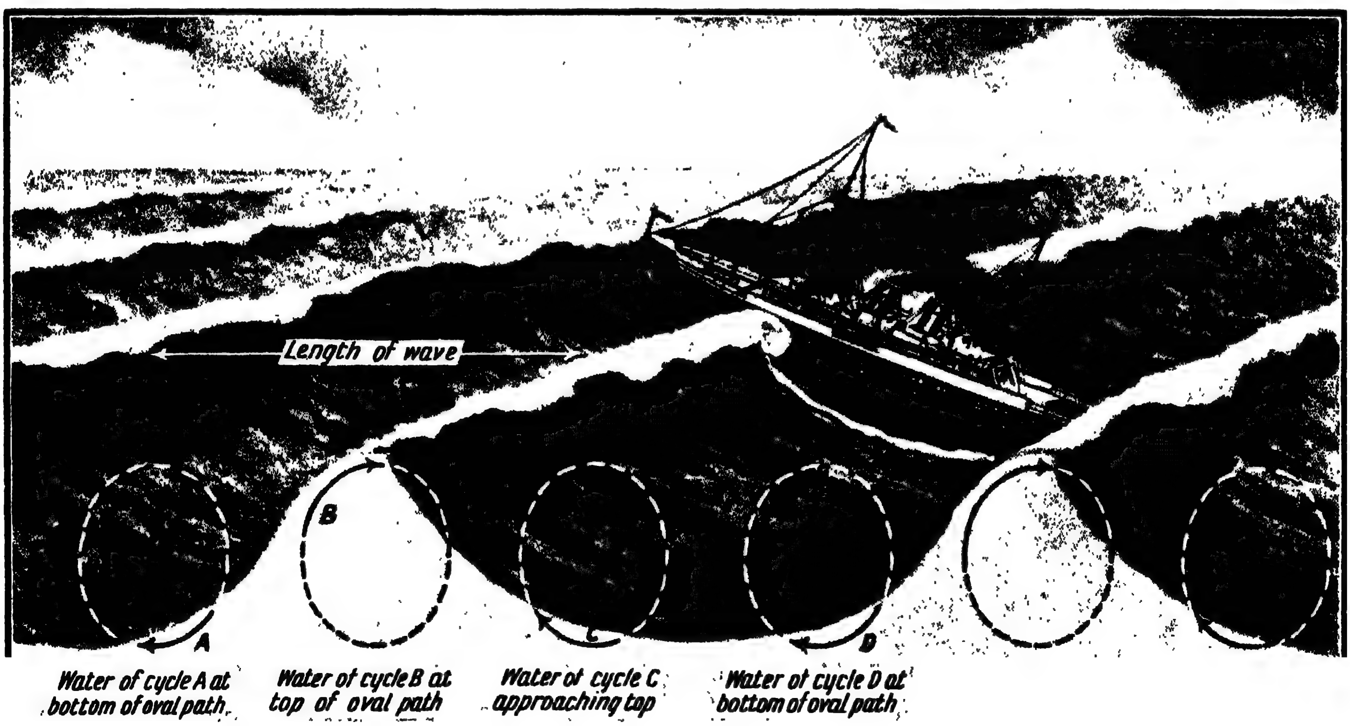


When the white snow falls it makes the world a fairyland. Even a dull street in a smoky city is made beautiful by the pure white flakes from the sky. But there is a beauty of the snow which is only seen by the careful observer who looks closely for it, and brings in the aid of a magnifying-glass or microscope. As they fall the snowflakes look very irregular in shape, but as a matter of fact they are not at all irregular. They are made up of delicate hexagonal, or six-sided, crystals of varying forms, and it is the rays of light reflected at the various surfaces, together with enclosed particles of air, that give the snow the appearance of whiteness. The snow crystals take the form of hexagonal plates, or six-rayed feathery stars. When we look at a snowflake through a lens we can see that it is made up of tiny ice crystals. In this picture we see the snow falling and some of the flakes as they appear to the observer through the microscope

WHY THE WAVE MOVES ON AND THE WATER REMAINS



These pictures explain the mystery of why the waves appear to travel forward while the water composing them remains in the same place. A cork floating on the sea, for instance, bobs up and down while the waves continue to pass it. The water of a wave really moves in an orbit. At A the particles of water are at the crest of a wave and as the wave moves forward the particles of water at A pass downward and then back in the trough and upward in front of the succeeding wave. At the same time the particles in the trough of the wave at B pass up and down again in an orbit So it is with the various groups of particles as the waves go on



Here the waves shown in the top picture have passed forward and the particles of water at A which were at the crest of the wave in the top picture are now at the bottom of the orbit. The particles that were at B in the first picture are now at the top of their orbit, and so on. As the waves pass on a ship meeting them rides up and down, passing alternately over the crest and down into the trough. The height of a wave is reckoned from the trough to the crest and in an average storm reaches generally 30 or 40 feet. It seldom exceeds 50 feet. The length of a wave is reckoned from crest to crest, and this varies from 300 to 1,500 feet or more. The speed of the waves also varies from 20 to 60 miles an hour. If the water moved forward with the waves the seas would not be navigable, for ships would be carried along and swept thousands of miles out of their courses

THE ADVENTURES OF A GREAT PATRIOT

Of all the great Scottish national heroes William Wallace stands first and foremost. The romance of his adventurous life and his dramatic fate has appealed to the imagination of all Scotsmen and of Englishmen too. Yet in actual achievement his life was nothing like so fruitful as that of the other Scottish hero, Robert Bruce, who really did free his country from English domination. In these pages we read the thrilling story of what William Wallace did for his country

When Alexander the Third of Scotland died in 1286 the heir to the throne was his little granddaughter Margaret, who was only three years old. She had been born in Norway, the daughter of King Eric of that country, and on that account has always been called the Maid of Norway.

Because she was so young guardians had to be appointed to rule the country, but they soon fell out and quarrelled among themselves.

A Queen Who Never Saw Her Country

Margaret's father was afraid that while his little daughter was growing up one of the guardians would make himself king, and so the child would lose her throne. He was very anxious that she should become Queen of both Norway and Scotland, and he therefore did a thing that caused untold misery for years to the Scottish nation.

He called upon Edward the First, the English king, to support the claims of Margaret, and Edward asked the six guardians to send representatives to England so that the matter could be discussed. This was done, and it was decided that Margaret should go to Scotland to reign when peace prevailed there. Further, she was not to marry anyone without the consent of her father and of Edward.

The English king had a great idea of marrying Margaret to his son, who afterwards became Edward the Second. This might have been a good thing because then the kingdoms of Scotland and England would have been united peaceably, but when soon afterwards Margaret sailed from Norway to Scotland and her ship stopped at the Orkney Isles she died there, so that she never even saw Scotland, the country of which she was queen.

Many Claimants to the Throne

There were now a dozen or more claimants to the throne of Scotland, for no direct heir existed, and Edward's help was again sought. He finally decided in favour of John Baliol, but he made the Scottish king do homage to himself as lord and master of the Scottish realm. The Scots resented this, and compelled Baliol to resist Edward, who thereupon invaded Scotland, defeated Baliol and carried away to London the famous Stone of Destiny on which the kings of Scotland had always been crowned. It was said to be the stone on which Jacob rested his head at Bethel when he dreamed of the angels ascending and descending between earth and heaven, and ever since it has had its place under the seat of the Coronation Chair in Westminster Abbey where all may see it.

Scotland was now completely subdued by Edward who ruled it with a rod of iron. Englishmen were sent to collect taxes, to try prisoners, and to occupy castles, and all their wants had to be supplied by the Scots. The English behaved like tyrants, and at last things became so unendurable that it needed only a brave man to rouse the nation and set Scotland ablaze. This hero was found, not among the great nobles, but in the son of a private gentleman. He was William Wallace, a tall, handsome, fair-haired man, one of the bravest who has ever lived, and he did great deeds for his country, which are as fresh in the memory of Scotsmen to-day as when they were first carried out.

William Wallace rejects the English peace offers

He had always detested the English for their cruelties and oppression, and he showed this hatred while very young. He had gone out fishing one day in the river Irvine near Ayr, and had caught a number of trout which a boy was carrying for him. As he walked he met some English soldiers belonging to the garrison of Ayr, who came up and insolently demanded the fish. Wallace offered to give them some, but refused to part with the whole basketful.

A Fateful Fishing-Rod

The soldiers, however, selfishly insisted on having all the fish, and when they started to take them by force Wallace, with the butt end of his fishing-rod, struck the foremost of the Englishmen under the ear, and killed him on the spot. Of course, the English governor of Ayr sent men out to seize him, but Wallace hid among the hills and woods till he could escape to another part of the country. Later on he married a lady of Lanark, and there he lived with his wife.

One day he was walking in the market place dressed in green clothes with a rich dagger by his side, when an Englishman called out some insulting remark about his finery, declaring that a Scotsman had no business to wear such a gay dress or carry so handsome a weapon. A quarrel followed, and then a fight in which Wallace killed the Englishman. He at once fled to his house, but English soldiers pursued, and as they entered the front door Wallace escaped by the back and got away to a rocky glen, where he hid himself.

The governor of Lanark, a man named Hazelrigg, was furious, and leading a party to Wallace's house burnt it to the ground and killed the brave Scotsman's wife and servants.

Wallace now determined to raise his countrymen and end the English oppression. He began by killing Hazelrigg to avenge the murder of his wife. Then he fought many successful skirmishes, and as nothing succeeds like success his countrymen soon began to flock to his standard.

A Treacherous Invitation

Those were rough times, and cruelties were practised on both sides. The English governor of Ayr invited a number of the Scottish nobility and gentry to meet him for a friendly conference on the affairs of the nation. He had treacherously determined to put

these Scotsmen to death, so in the building, a great barn, where the meeting was to take place he made the English soldiers hang halters with running nooses over the beams which supported the roof. Then, as the Scottish gentlemen were admitted two at a time, the nooses were thrown quickly over their heads and they were pulled up by the neck and hanged till they were dead.

The "Barns of Ayr"

Among those who suffered as a result of this treachery was an uncle of William Wallace. Wallace, when he heard what had happened, was naturally very furious He collected his men and determined to avenge their crime in a terrible way. The English soldiers celebrated their cruel deed with feasting and drinking, and, having no fear that Wallace was near, lay down to sleep in some buildings including the large barn which had been the scene of the murders, setting no guards or sentries to watch.

Wallace directed a woman who knew the place well to mark with chalk the doors of the buildings where the Englishmen lay. Then he sent a party of his men secretly with strong ropes and they fastened all the doors from the outside so that those within could not open them. The Scots next piled heaps of straw against the wooden buildings and when all was ready set light to the straw In a moment the whole place was ablaze. The Englishmen woke up and tried to escape, but the doors were fastened, and when they tried to get out in other ways they were driven back or killed on the spot It was a terrible revenge for a terrible crime, and the whole incident has come down in history by the name of the "Barns of Ayr."

No Compromise

Wallace's party now grew stronger and stronger, and the English felt that they must defeat this man or their position would be impossible in Scotland. They, therefore, gathered an army and went out to meet Wallace near the town of Stirling But before fighting, the English were persuaded by a Scottish adherent to try the effect of persuasion upon Wallace. Two monks were chosen to carry proposals of peace to the Scottish leader. They found his army encamped on a hill, and delivered their message, but Wallace would have nothing to do with compromise.

"Tell your countrymen," he said to the monks, "that we have come here not for peace but for war, to revenge ourselves and liberate our country Let them come on, we will meet them to their beards."

The envoys returned with this message to the English commander, and although he himself was not so eager to fight, the rank and file in the English army hailed Wallace's defiance with fierce joy.

After some discussion the order was given to advance across a bridge which separated the two armies When about a fourth of the English had passed the Scots poured down upon them from the hill, and rushing impetuously on their enemies cut the English army in two Nearly all who had crossed the bridge, and the number was about 5,000, fell beneath the Scottish weapons, or were drowned while trying to escape. Their commander and the main body of the English army on the other side looked on helplessly, unable to avert the fate of their companions. The result was that the English were defeated, and the English guardian and treasurer of Scotland, Hugh de Cressingham, was slain

Grim Souvenirs of a Tyrant

He had been a great tyrant, and the Scots detested him so much that they flayed the skin from his body and kept fragments of it as souvenirs of the revenge that they had taken upon their enemies. It is said that some of them made saddle girths of this same skin.

Wallace was now regarded as a great leader, and he is honoured in Scottish history as one of the two greatest national heroes that the country has produced. In the course of time his cruelties have largely been forgotten or passed over, and he is regarded as a fine and gallant gentleman. But in those rough times all warriors were more or less cruel and Wallace was no exception His own countrymen recognise this and Sir Walter Scott tells us that "Though Wallace disapproved of hanging priests, women and children, he partook of the ferocity of the times so much as to put to death without quarter all whom he found in arms."

When he attacked Dunnottar and the English garrison fled into the church, Wallace caused the church to be set on fire and let those inside scream in vain for mercy. When his followers, frightened at such a scene in a church, fell on their knees and asked the priests in the army to forgive them, Wallace only laughed and said, "I will absolve you all myself. Are you Scottish soldiers and do you repent for a trifle like this?"

A King in a Great Rage

While all this was going on in Scotland, Edward the First was waging war in Flanders, but he soon came back in a great rage and, gathering a large army, marched into Scotland declaring that he would never leave it till the whole country was finally conquered. All his efforts might have been in vain, had not jealousy begun to work among the Scots. The nobles were angry that a simple gentleman like Wallace should have done what they were unable or unwilling to do, and they failed to support him. This was fatal, for if the English were not again to obtain control of the country, the whole nation must work and fight together loyally.

The English Archers

Wallace gathered an army, but there were not many warriors on horseback, for the nobles would not help him The English king, on the other hand, had a very fine body of cavalry all clothed in armour, and well armed. He also had a large body of archers and at that time there were no finer archers in the world than the English Each one had twelve arrows stuck in his belt, and it was said that every English archer carried twelve Scotsmen's lives under his girdle, for every arrow was expected to kill a man.

When the battle was about to begin, Wallace said to his soldiers, "I have brought you to the ring; let me see how you can dance," his meaning being, of course, that having brought them to the field of battle he wanted them to fight bravely

The greater part of the Scottish army was on foot, the men being armed with long spears. He arranged these men in four circles. Those in the

A loaf was turned upside down as a signal and men rushed in and seized Wallace

front rank knelt down on one knee, holding their spears forward, then the other ranks pointed their spears over the shoulders of those in front. With all the spears thrown out in this way the circles were almost impregnable.

Between the circles Wallace placed his archers, and behind them the few horse soldiers which he had with him It was very unfortunate for the brave Scottish leader that as soon as the battle began, his horse soldiers, with great cowardice, fled without striking a blow. Probably this was due to the treachery of the nobles who disliked Wallace.

The English horse soldiers, instead of riding at the circles, rushed down upon the Scottish bowmen, and as these had nothing but their bows and very short swords to fight with, they were soon slain by the horsemen who were protected by coats of mail. These archers fought bravely, but almost every one of them fell on the field.

The English knights now tried to break the rings of Scottish spearmen, but failed. Then the English bowmen did what the Norman archers did at the Battle of Hastings. They directed their arrows at the spearmen, and soon there were gaps in the ranks through which the English knights were able to ride. The battle was lost, and after making a bold stand Wallace and the remnants of his army retreated into a forest known as Tor Wood. This decisive battle took place at Falkirk.

The Trial of Wallace in Westminster Hall, from the painting by Daniel Maclise

Scot Betrays Scot

With the defeat of Wallace the hopes of Scotland perished, but the great patriot would not give in, and he went on fighting against the English whenever he had the chance. Edward realised that he must destroy Wallace if he was to conquer Scotland, and so he offered a large sum of money to any who would bring in the leader alive or dead. At last he was taken by treachery, and the records tells us that it was a Scotsman, Sir John Menteith, by whom he was seized and delivered to the English.

The story goes that Wallace was at Robroyston, near Glasgow, when he was betrayed. So fierce a patriot was he that none dared try to take him alone, and it was decided that many men should rush upon him at a given signal. A pretended friend was to turn a loaf upside down on the table. The signal was given, the party rushed forward, and Wallace was a prisoner. For years afterwards it was considered the worst of ill-manners if anyone turned a loaf upside down in the presence of any person named Menteith.

There was little chivalry to enemies in those days, and Edward the First, having captured his great foe, resolved to make a terrible example of him, so as to warn all other would-be Scottish patriots against following in his steps.

Wallace was taken to London, and he knew he could expect no mercy, for Edward regarded him as a traitor to the English crown, although, of course, that was not in any sense true.

He was taken through London to Westminster Hall, and there brought to trial before English judges. In mockery he had been crowned with a green garland, the English declaring that he was the king of outlaws and robbers.

When charged with being a traitor, Wallace said: "I could not be a traitor to Edward, for I was never his subject." He was then charged with having captured and burned towns and castles, with having killed many Englishmen, and with having committed many other acts of violence.

To this he replied that it was quite true that he had killed many Englishmen, but this was only because they had come into his native land to subdue and oppress it. "So far from repenting of what I have done," he declared, "I am only sorry that I did not put to death many more Englishmen."

An Unforgotten Example

Lawyers who have studied the trial of William Wallace tell us that his defence was a good one, both in law and in common sense, but nevertheless the English judges condemned him to a cruel death. He was dragged on a sledge to the place of execution where his head was struck off. Then his body was divided into four parts, according to the cruel custom of the time, and while his head was placed on a pole on London Bridge as a warning, the other parts of his body were sent to Newcastle, Berwick, Stirling, and Perth, so that the people in those parts might be terrified by his terrible fate and so prevented from following in his footsteps.

After Wallace's death Scotland was conquered and English soldiers were again placed in all the chief castles and towns. Wallace's example was not forgotten, and although he died more than six centuries ago, his countrymen still honour him as one of the greatest characters that Scotland has produced.

Alexander Pope wrote truly when he said: "The Scots will fight for Wallace as for God," and Burns pays tribute to his famous countryman in the lines:

> At Wallace's name, what Scottish blood
> But boils up in a spring-tide flood,
> Oft have our fearless fathers strode
> By Wallace's side,
> Still pressing onward red-wat-shod
> Or glorious dy'd.

The great English historian, John Richard Green, tells us that "The instinct of the Scotch people has guided it aright in choosing Wallace for its national hero. He was the first to assert freedom as a national birthright and amidst the despair of nobles and priests to call the people to arms."

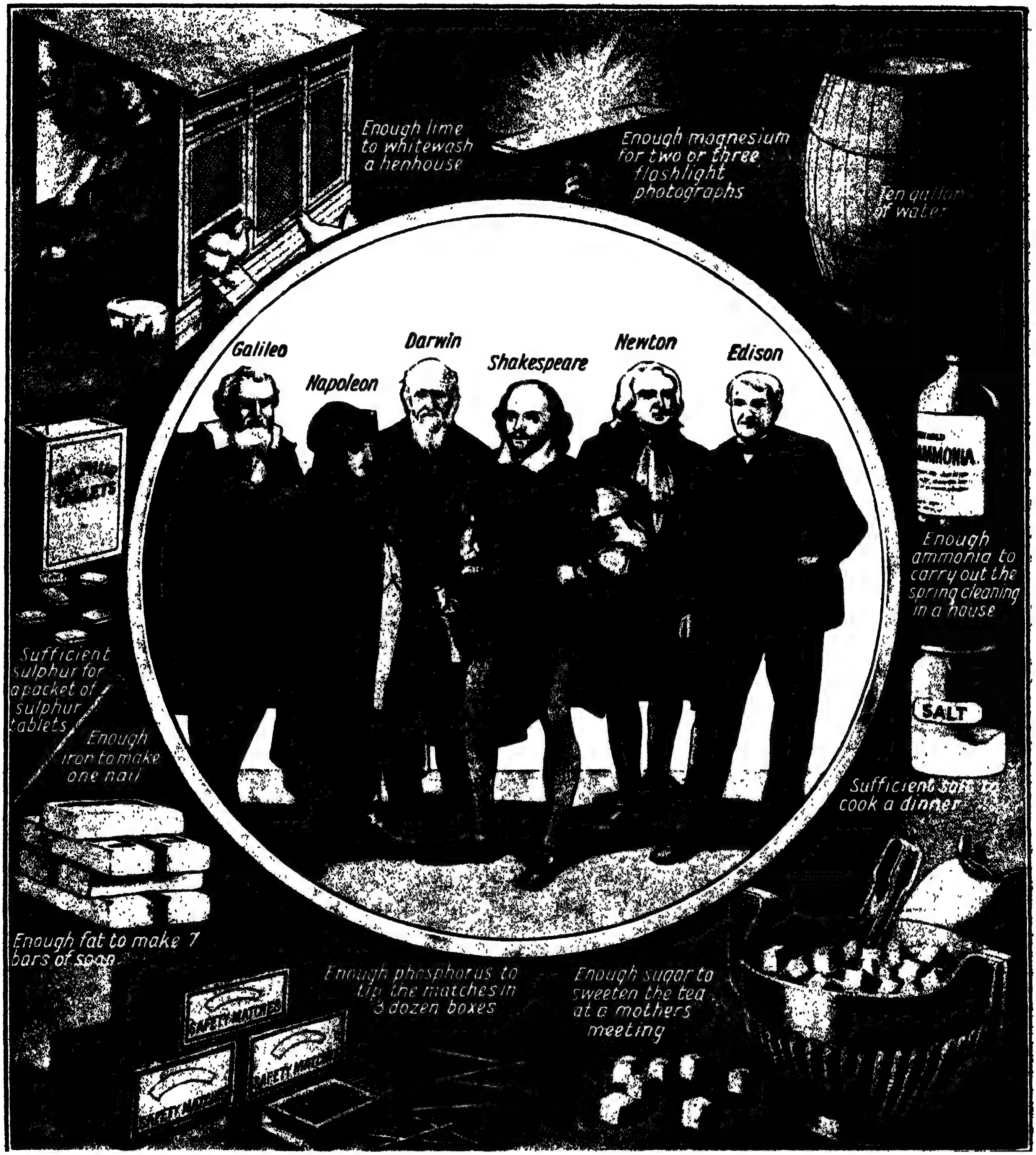
Another historian declares that Wallace's name stands brightly forward among the foremost of men, with Gustavus Vasa, the great Swedish hero-king, with the two Williams of Orange, with George Washington, with Kosciusko, the gallant Polish patriot, and with his own more fortunate successor, Robert Bruce.

A former English Poet Laureate, Robert Southey, has paid the Scottish hero a fine tribute in his poem, "The Death of Wallace."

> They throng to view him now
> Who in the field had fled before his sword,
> Who at the name of Wallace once grew pale
> And faltered out a prayer.
>
> Yes, they can meet his eye,
> That only beams with patient courage now,
> Yes, they can gaze upon those manly limbs
> Defenceless now and bound.
>
> And that eye did not shrink
> As he beheld the pomp of infamy,
> Nor did one rebel feeling shake those limbs
> When the last moment came.
>
> He called to mind his deeds
> Done for his country in the embattled field;
> He thought of that good cause for which he died,
> And it was joy in death!

Wallace's memory is now the heritage of both the Scottish and English people, happily united in the one brave race.

THE ACTUAL VALUE OF A GREAT MAN



Who can estimate the value of such men as William Shakespeare, Charles Darwin and Thomas Alva Edison ? Their services to the world have been so great that it would be impossible to give them any money value. Their price is above rubies. Yet there is a sense in which the money value of any man or woman or child can be reckoned up with fair accuracy. If we consider a person only from a material point of view, that is, the amount of matter in his body, the part of him that we can handle and see, then the worth of even a Shakespeare or a Napoleon is very small indeed. A scientist has with some humour reckoned up the value of a full-grown man's body as a few shillings, and above we see what it consists of. It makes no difference whether the man is a genius like the men shown in the middle of the picture, or a dullard. Indeed, often an ignorant and foolish person may be worth more in this sense than a genius, for his body may be very big and stout, so that there is more material in it. Of course our bodies, like everything else in the world, are made up of combinations of elementary substances like oxygen and hydrogen and carbon and nitrogen and phosphorus and sulphur, with a few metals like calcium and iron. It is interesting to know how little the material of our bodies is worth, but, at the same time, we must remember the great value of the human body as a channel for expressing the wonders of the mind

WHAT ARE YOU REALLY WORTH?

What are you worth? It all depends upon yourself. If you make good use of your opportunities so that you grow in knowledge and wisdom, and are keen and industrious to make use of such advantages, you are worth much to the world. But if you think only of the material of which your body is made you are worth very little indeed. Here are some interesting and amusing facts about what a man is worth in this sense

THINK of the world as it was ten thousand years ago, and as it is to-day, with its beautiful buildings, its steamships and railways, its motor-cars and telephones, its wireless and cinemas, and the thousand and one other comforts and luxuries which we all enjoy. How has the change come about?

Well, it has been achieved by men who were full of enterprise and made use of the opportunities they had of discovering the secrets of nature and harnessing the natural forces around them. The comforts and conveniences and liberty and refinement we enjoy to-day we owe to men like Archimedes, St Francis of Assisi, William Shakespeare, John Hampden, Sir Isaac Newton, Sir Christopher Wren, James Watt, George Stephenson, Thomas Alva Edison, Sir Charles Parsons, and Marconi. Who can estimate or appraise the worth of such men to mankind? To use the old phrase, we may well say "their price is above rubies"

The Triumph of Mind

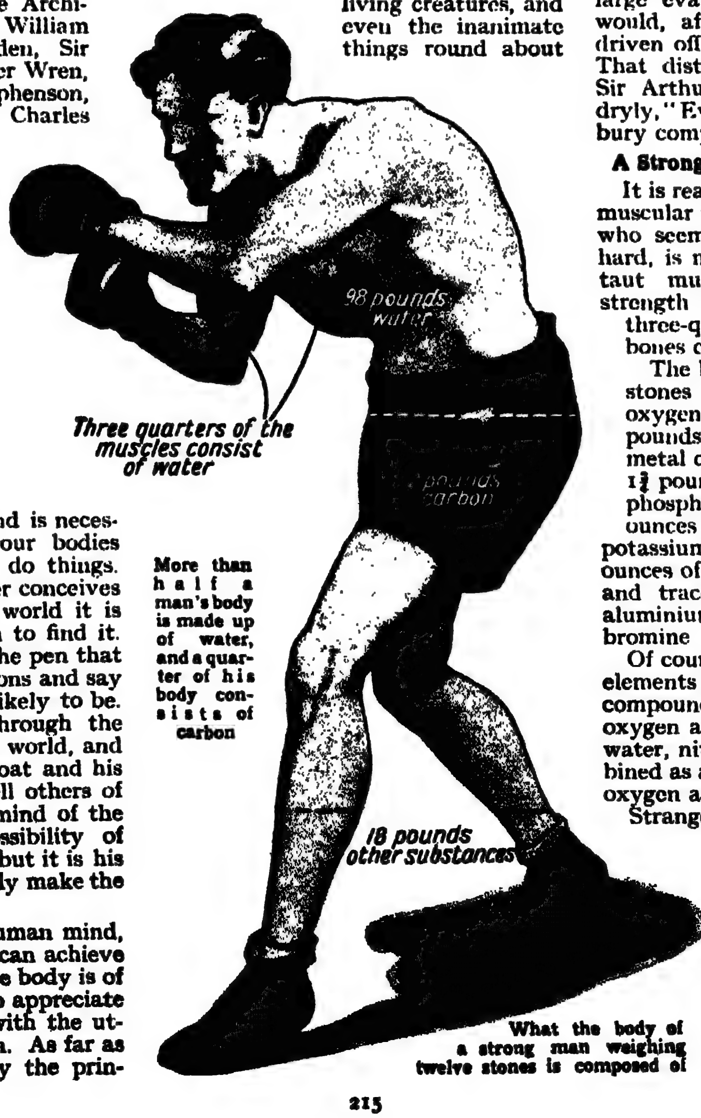
But when we think of the worth of a man we are naturally taking into consideration his mind and achievements. It is the mind of man that triumphs over the forces of nature. Yet to achieve anything, something more than a mind is necessary. It is by means of our bodies that our minds are able to do things. If the mind of an astronomer conceives the existence of a distant world it is his body which enables him to find it. He uses his hands to hold the pen that shall work out the calculations and say where the distant world is likely to be. It is his eye that looks through the telescope and discovers the world, and it is his tongue and his throat and his lips that enable him to tell others of his great discovery. The mind of the engineer conceives the possibility of making steam do his work, but it is his hands and arms that actually make the steam engine.

Without the body the human mind, however highly developed, can achieve nothing. Because of this the body is of great value, and we need to appreciate its worth and to treat it with the utmost care and consideration. As far as in us lies, we should study the principles of hygiene and keep our bodies healthy and strong in order that they may carry out the ideas which our minds conceive and put them into operation for the benefit of the world. St. Paul had something like this in his mind when, writing to his friends, he reminded them: "Know ye not that your body is the temple of the Holy Ghost?"

But although the body as an agent and instrument of the human mind is so important, and even essential, there is another sense in which it may be said to be worth very little indeed.

Like all other living creatures, and even the inanimate things round about us, our bodies are made up of certain chemical substances, and a scientist has estimated the value of the actual material in a man's body. He says that it is worth only a few shillings. Think of it, the body of a millionaire or a beggar, a Newton or a navvy, is worth less than the shoes or the hat he wears! But, on the other hand, a fat man, even if he be only a doorkeeper or a dustman, is worth more in this sense than a thin or short man, though he be Chancellor of a University or even a Napoleon.

In the first place more than half the body consists of water. If a man weighing 12 stones were put into a large evaporating dish and dried he would, after all the water had been driven off, weigh less than five stones. That distinguished scientist, the late Sir Arthur Shipley, once said rather dryly, "Even the Archbishop of Canterbury comprises fifty per cent water."



More than half a man's body is made up of water, and a quarter of his body consists of carbon

What the body of a strong man weighing twelve stones is composed of

A Strong Man more than Half Water

It is really astonishing that a big and muscular man like a champion pugilist, who seems so strong and can hit so hard, is more than half water. Those taut muscles which give him his strength are made up of more than three-quarters water. Even the solid bones contain 27 per cent. of water

The body of an average man of 12 stones contains about 96 pounds of oxygen, 52 pounds of carbon, 15 pounds of hydrogen, 4 pounds of the metal calcium, 3½ pounds of nitrogen, 1¾ pounds of chlorine, 1¾ pounds of phosphorus, 3½ ounces of sulphur, 3½ ounces of fluorine gas, 2¾ ounces of potassium, 2½ ounces of sodium, 1¾ ounces of magnesium, 1¼ ounces of iron, and traces of copper, lead, arsenic, aluminium, manganese, silicon and bromine

Of course in the body these chemical elements are combined to form various compound substances For example, oxygen and hydrogen are combined as water, nitrogen and hydrogen are combined as ammonia, calcium, carbon and oxygen are combined as lime.

Strangely enough, says a scientist, a woman's body is worth rather more than a man's, as it has a greater proportion of the more costly materials.

What an astonishing thing it is that so little chemical material when endued with that mysterious spark called Life, can become priceless!

HOW MISTLETOE RUINS THE TREE IT GROWS ON

A PLANT which lives at the expense of another is called a parasite, a word that has come to us from the Greek and means "one who eats at another's table." This is really what a plant like the mistletoe does. It is the most striking example of a parasite plant found growing in Great Britain.

We may see it sometimes growing in clumps on an apple or poplar tree, and it is an enemy of the tree, for it saps the life of its host, getting its nourishment from the tree instead of from the ground. It is quite different from the ivy or other creeper which grows up a tree and often strangles it to death. That plant also is an enemy of the tree, but it is not a parasite, for it has roots in the ground and draws its nourishment from the soil.

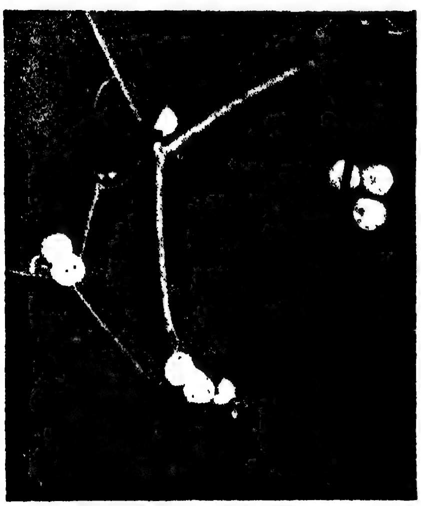
The life story of the mistletoe is interesting. Birds seize the berries, but as these have sticky matter round them they cannot be swallowed and so the birds scrape them off their beaks on to the branches of trees There they remain and germinate.

How the mistletoe eats into the tree which it lives upon, and eventually kills its host. The branch is shown in section at the top

The plant has no ordinary roots but puts out modified roots known as sinkers, and these find their way under the bark of a tree's branch and their wood then becomes attached to the new wood of the branch inside the bark. The sinkers draw water and mineral food from the host, and thus the mistletoe is fed. It puts out green leaves containing chlorophyll, and these under the influence of sunlight are able to take up carbon dioxide, so that the mistletoe is partly able to maintain itself. The plant is therefore not entirely dependent on its host for food, and it is regarded by botanists as a partial parasite.

Another British plant, which is a complete parasite, entirely dependent on its host for food and water, is the dodder, which may often be seen growing on such plants as clover, nettle and gorse, and twining round them.

Flowers of the mistletoe plant



The white berries of mistletoe

Bunches of mistletoe growing on a tree. The parasite will eventually kill the tree by inserting its sinkers, slowly eating into its branches, thus stealing its nourishment

A TREE THAT GIVES THE TRAVELLER DRINK

One of the most striking and useful plants in the world is known as the Traveller's Tree, and is found growing in Madagascar and in Brazil and Guiana. The South American species is remarkably like that found growing in the great African island. The plant is a member of the banana family, and its leaves are very much like those of the banana, though larger. They are said to be the largest leaves to be found in the whole of the plant world, except perhaps for those of the giant lily known as the Victoria Regia. Sometimes the Traveller's Tree is quite short, with the leaves all growing from the root, while at other times it has a stem thirty feet or more high, with leaves growing on great stalks at the top, while on the lower part of the stem are the scars of old and decayed leaves. The plant was given its name of Traveller's Tree because of a very useful property which it has. It stores up water in its long, concave leaf stalks, and when these are cut they yield a good supply of clear, watery sap, which, although not altogether pleasant to the taste, is very useful if a traveller is short of water. The stalks are divided inside into small cubical chambers, about half an inch square, and it is in these that the water is stored. In describing the Traveller's Tree writers have sometimes said that it provides water for the weary and thirsty traveller in the desert, but, of course, this is not so, as the plant does not grow in the desert

THE SHIP OF THE DESERT AND ITS WORK

There are no really wild camels in the world to-day, although there are a few half-wild herds which have come from domesticated camels that have escaped from captivity. Of the two species of camel, the Arabian, with one hump, and the Bactrian, with two humps, the Arabian is the better known. It is the camel that is found in Egypt and Arabia, and here we read many interesting things about it

The Arabian camel is not a pretty animal, nor is its head beautiful, and its temper is something like its appearance, rather unpleasing.

It stands about seven feet high and has a long neck, and its hump varies a good deal in size and uprightness, according to the supply of food which is available. In the rainy season when there is more herbage, the hump gets large, stands upright and forms a regular pyramid, while in the dry season when food is difficult to get and the camel is half starved, the hump almost disappears.

Camels Unfit for Moist Regions

No one can say for certain where the Arabian camel originated although, as its name implies, its early home was Arabia. This camel is peculiarly fitted for the circumstances in which it has to live, namely, dry and desert districts, and for this reason attempts to introduce it into moister regions like Southern India and Central Africa have failed. Attempts also to acclimatise the Arabian camel in the dry regions of the United States such as Arizona and New Mexico have not been successful over any long period.

The natural food of the camel is the branches and leaves of trees, but now it is fed largely on grain, although a certain amount of green food is necessary if the camel is to be kept in health. The inside of the camel's mouth must be very tough, for it can eat the thorniest of boughs without inconvenience, and scientists marvel that the mouth does not get injured.

So long as the camel can get food of the right kind—and even dates will sustain it—it will work well over long periods, but if it is not fed regularly it soon breaks down.

It is a surly beast, and never becomes really attached to its master, and during the pairing season it gets fierce attacks of rage, and becomes so savage as to be dangerous. At such seasons it has been known to bite off the top of a man's head.

The camel is very jealous and revengeful. A certain camel driver had thrashed the animal under his charge, and the camel showed a disposition to resent this. But the driver, judging from the expression of its eye what was passing within, kept on the alert for several days.

One night, instead of sleeping outside, he retired for safety to the interior of his tent, leaving his striped cloak spread over the wooden saddle of the camel outside the tent. During the night the driver heard the camel approach this object, and having satisfied itself, by smell or otherwise, that it was its master's cloak, and believing that the man was asleep beneath it, the animal lay down and rolled backwards and forwards over the cloak, apparently gratified by the cracking and smashing of the saddle under its weight, and fully persuaded that it was breaking the bones of its master. After a time it arose, looked at the disordered mass, apparently with great contentment, and then retired.

Next morning at the usual hour for loading, when the master presented himself to the camel, the disappointed animal is said to have been so enraged that after a time it fell dead on the spot.

The camel is not a swimmer, though there are some camels that can swim a little. But they dislike very much crossing even a small stream. When it is desired to take camels across a river they are usually supported by inflated skins.

It has been said that without the aid of the camel in crossing deserts the mighty civilisations of the ancient world could never have been accomplished in Asia, Arabia or North Africa.

The Race-Horse of the Camel Family

There are various breeds of the Arabian camel, which differ as much from one another as do race-horses from cart-horses. Baggage camels will carry a great load at a rate of two and a half to three miles an hour for six hours a day, but the dromedary, which is simply a well-bred Arabian camel, can travel at from eight to ten miles an hour for a long time. The dromedary is really the race-horse among camels. Many run 70 miles a day, and can keep this pace up for days together.

The Arabs have a saying that the camel is the greatest of all blessings given by Allah to mankind. Its long neck gives wide range of vision in desert marches, and enables it to reach out to the desert shrubs on either side of the pathway. The cartilaginous nature of the mouth enables it to eat hard and thorny plants, the pasture of the desert. The ears are very small and the nostrils, large for breathing, are specially capable of closure by valve-like folds against the fearful simoom or sandstorm. The eyes are prominent, but protected by heavy, overhanging lids, limiting vision upward and guarding from the direct rays of the noon sun.

A Reservoir of Food

The hump is not a fictional but a real and acknowledged reservoir of nutriment, as well as Nature's pack-saddle for the commerce of the ages. All that can be obtained from the camel is of value; fuel, milk, excellent hair for tents, ropes, shawls and coarser fabrics are obtained from the living animal; and flesh food, leather, bones and other useful substances from the dead.

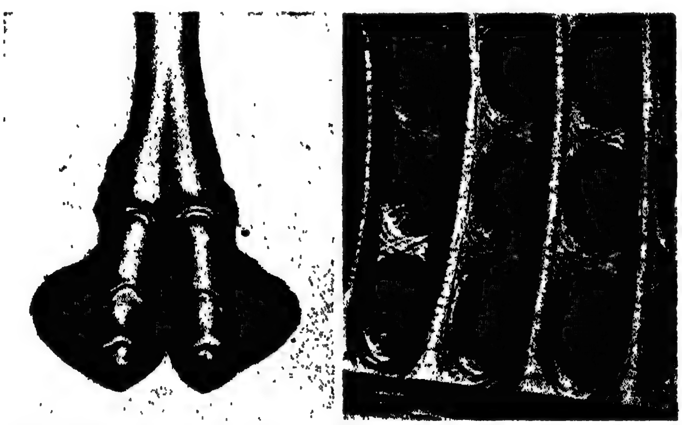
A camel march is the standard measure of distance in all Arabia, and the price of a milch camel the standard of value in the interior. Camel's milk is the staple diet of thousands in Arabia.

So writes an Arabian traveller.

It is particularly interesting to note that the camel is the filter of the desert. It can drink the most undrinkable water from desert wells which would be absolutely useless for mankind, and filtering this water in its body, present it in useful form to man as milk. Many a man travelling across the desert has sustained himself almost entirely on camel's milk.

The stomach has a large number of water cells, and in these a great deal of fluid can be stored for the use of the camel. But it is quite undrinkable by man, and stories about the slaying of camels to get at the water stored up in their stomachs are untrue. The camel's stomach, however, contrary to popular belief, is not so complicated as, say, the stomach of a sheep, described in another part of this book.

Just as it stores water in its stomach, so it stores food in its hump, which provides reserve material for the camel when food is difficult to get.

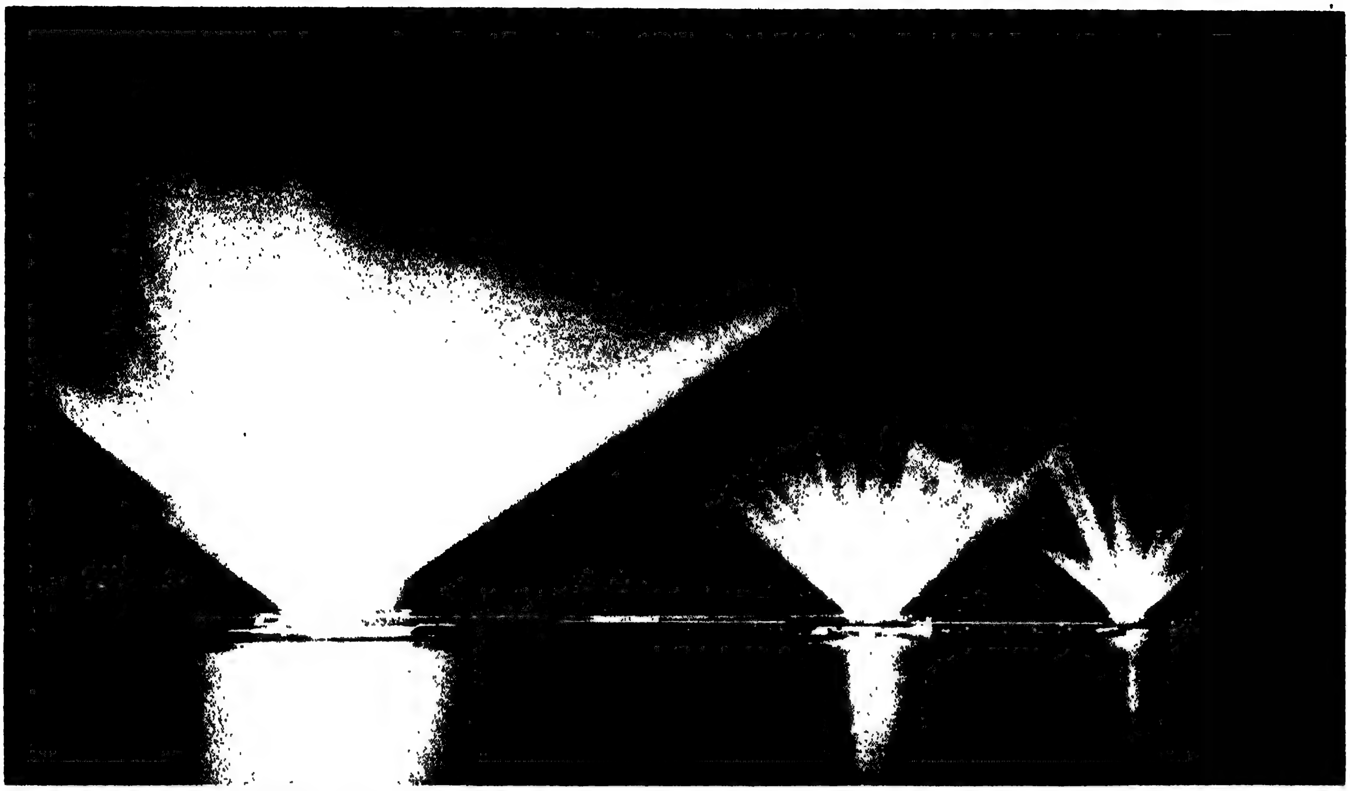


The camel's foot showing the relation of the bones to the wide pad which enables it to travel easily over sand. On the right we see some of the water pockets in the camel's stomach where it stores up water

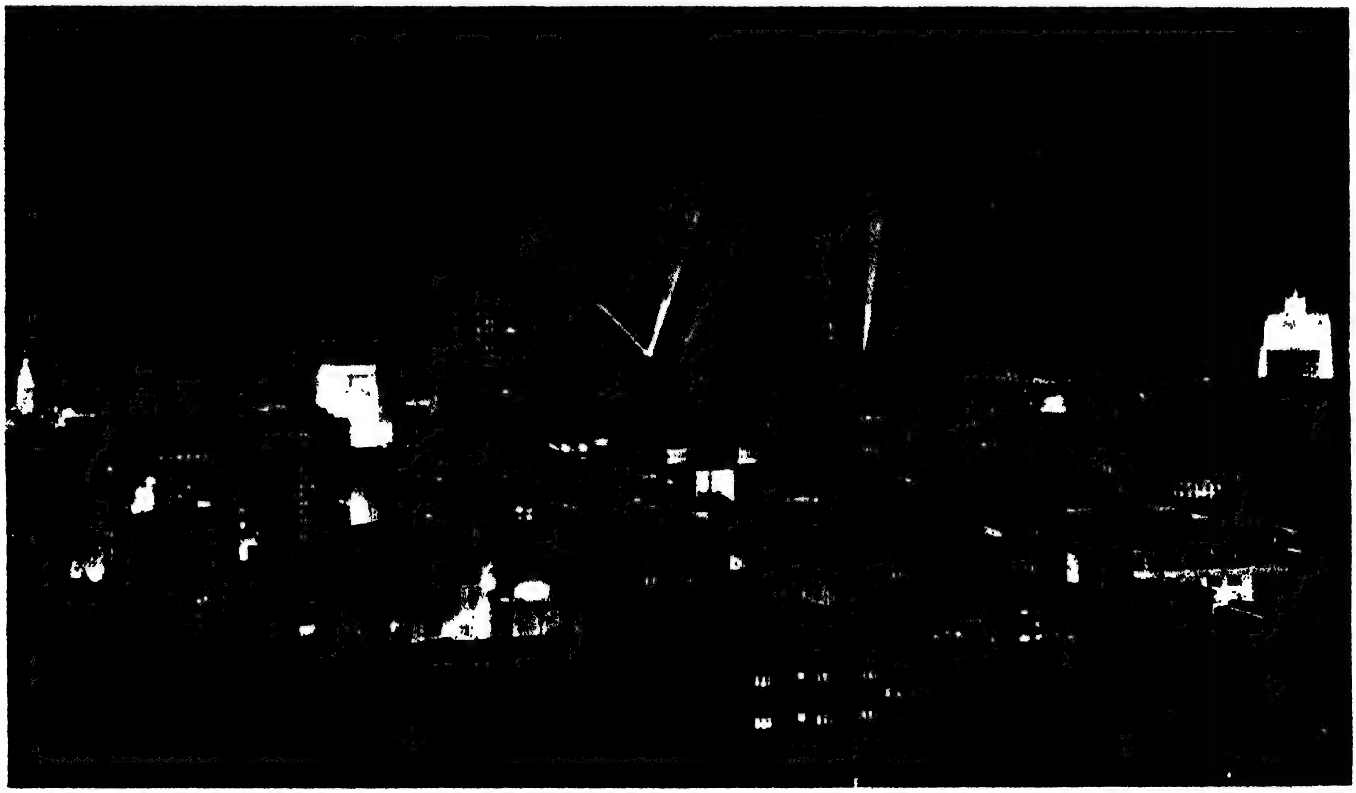
THE ARABIAN OR ONE-HUMPED CAMEL

It is not known whether the one-humped camel is a native of Arabia or of the African continent. Indeed, very little is known about the origin of the camel, but it was a familiar domesticated animal in Egypt at least 32 centuries ago. There are no really wild camels in the world to-day, either of the one-humped or the Bactrian or two-humped species. The early civilisations were largely dependent on the camel for transport across wide areas. Here we see an Arabian camel with a young one

Although the Arabian or one-humped camel is an exceedingly useful beast, it is surly and never becomes really attached to its master. During the pairing season it has fierce attacks of rage and sometimes becomes dangerous. It has even been known to bite off the top of a man's head. But in the dry, arid regions of North Africa it is the only animal that can be kept profitably. It can travel long distances at a steady pace carrying a considerable load, and is very useful also for yoking to the plough, as shown in this photograph by Donald McLeish, taken in the Egyptian Sahara. The camel can also live on very scanty fare



Light always travels in straight lines, and that is why we cannot see round a corner, unless by means of a mirror we bend back the ray of light into another straight line. This picture shows a number of battleships giving a display with their searchlights, and, as we can see, in whichever direction the light is travelling from its source the beam is perfectly straight. Whatever may be the kind of light and whether or not the beams are visible to us along all their course as in the case of the searchlights, the same fact is true



In this picture we have another illustration of how light travels in straight lines. The beams in the background are the searchlights of warships in San Francisco harbour. As the lights are turned about the beams change their directions, but always remain straight. In the same way the rays from the lighted windows of the buildings travel to the eye of the spectator and to the camera which takes the photograph, in straight lines, although in these cases, the light being less intense, the direction of each beam is not seen along its whole course

WHY WE CANNOT SEE ROUND A CORNER

There are many interesting things that we ought to know about Light and one is the fact that it travels in straight lines, although sometimes it may seem not to do so. You can never see a thing round a corner, although by setting up a mirror you may see a reflection of what is round the corner. The rays of light, however, are in that case still travelling in straight lines. Here we read more about this interesting and important property of light

HAVE you ever wondered why, although you can hear round a corner, you can never see round a corner ?

If you are in the hall and your friend is inside a room with the door almost closed, you can carry on a conversation with him but you cannot see him. This seems strange, because both sound and light come to us in the form of waves. The sound waves, however, are waves in the air, and these can travel in any direction.

When your friend speaks he sets up waves which travel from his mouth to the opening in the doorway and round the corner to where you are standing. They travel equally well upstairs or downstairs or indeed in any other direction.

But it is quite different with light waves. These are not waves in the air, but in the ether, and they travel only in one direction, that is, in a straight line. You can see for yourself how light travels in straight lines by watching the rays of a searchlight, and you can get an equally striking demonstration in your own house.

Proof by Experiment

Close the shutters on a sunny day, or if there are no shutters place a dark blind or several thicknesses of brown paper over the window, shutting out all the light. Then make a small hole, so that the sun can shine through this. If you stir up the dust in the room so that there are plenty of particles of dust to reflect the light as it passes from the opening in the blind, you will see that the light travels in a straight line or beam from the opening to the wall or floor.

There is another very simple experiment by which you can prove that light travels in a straight line. Take a number of cards, say four, and pierce a hole in each in the same position. Stand these upon the table, supporting them by means of books, as shown in the picture on the next page.

Now light a candle and place it at one end, while you peep through the hole of the first card at the opposite end. Unless you get all the four holes in a direct line you will be unable to see the flame of the candle. The slightest deflection of any of the cards and the light will be shut off from your eyes. It can only travel in a straight line.

This is all very interesting, but there is something that seems to contradict it. If, when you are carrying on the conversation with your friend while you are outside the door of the room, and he is inside, there happens to be a mirror facing the door, you can see a reflection of your friend in the mirror. In a sense it can be said that you see him, while he is round the corner.

But, of course, you are not looking at him but only at his reflection, and the fact still remains that light travels in straight lines. The light from your friend reaches the mirror in a straight line. This is then reflected or bent back by the silver on the back of the glass and again the light travels in a straight line from the mirror to your eye.

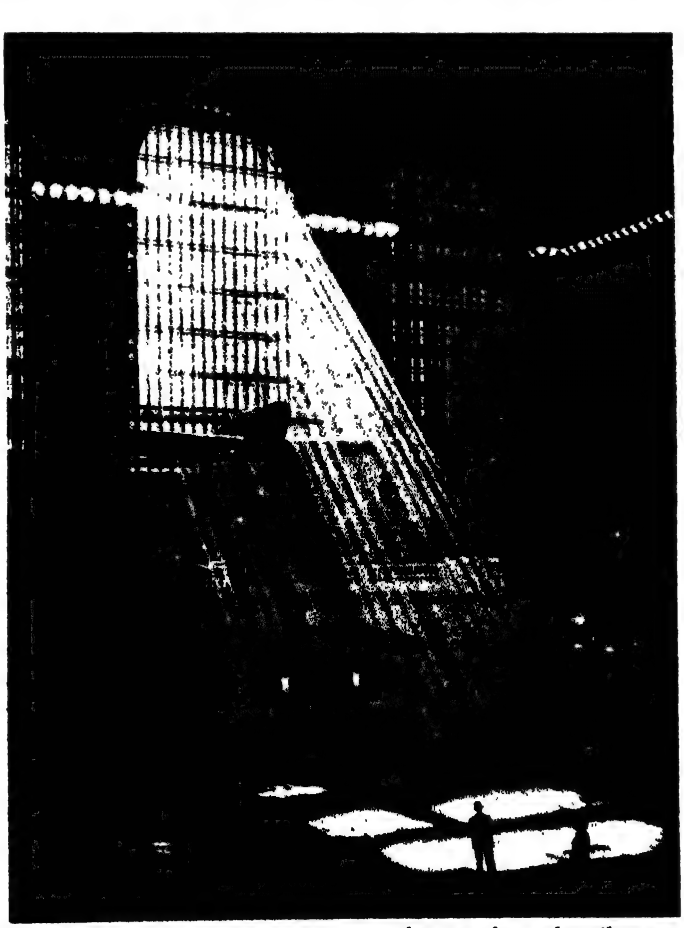
In the trick on page 65, whereby you seem to be looking through a brick, the light rays are reflected by mirrors, but they all travel in straight lines. It is not the light you see through the brick but its reflection.

There are still other appearances that seem to contradict the statement about light always travelling in a straight line. For example, if you place a stick in a pail of water, from the point where the stick enters the water it seems to be bent. The same thing happens if you are punting. The punt pole where it goes into the water appears bent at an angle.

Series of Straight Lines

But these curious appearances do not really contradict the fact that light travels in a straight line. There is, however, an additional fact which it is important to know, and that is this: when a ray of light that has been travelling along a straight line in the air enters some other substance, such, for example, as water or glass, it is bent or refracted, as scientists call it, into another line. Then this second line goes straight on until it passes into another substance, as, for example, when it passes out of the water or glass into the air again. Here it is bent a second time, and then goes on once more in a straight line.

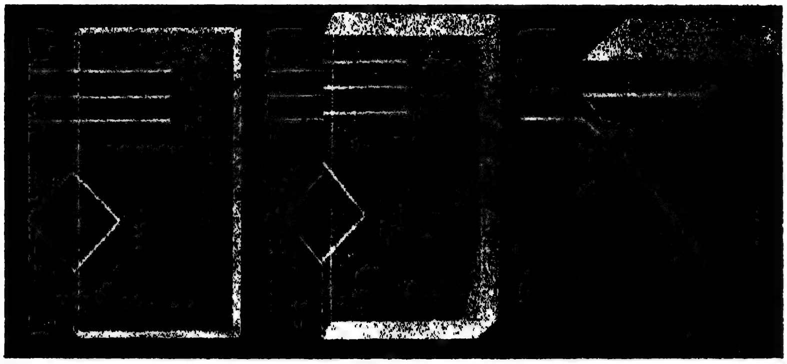
This is what happens with the stick in the pail of water and the punting pole in the river. There is another curious thing, however, about the rays of light. If the rays fall perpendicularly on a surface there is no refraction. It is only when they fall slantingly that the rays appear bent. You can



That light rays are straight we can see for ourselves when the sunshine enters through narrow openings into a chamber where there is plenty of dust in the air. The light as it passes is reflected from particle to particle and we see the straight beams of light

prove this by a very simple experiment.

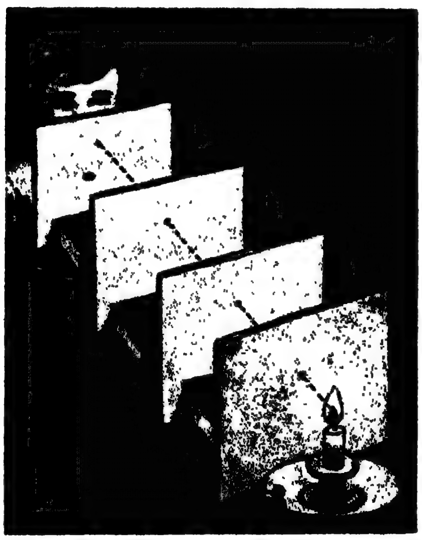
Take a piece of thick plate glass, place it on some lines or printed letters, in such a way that the edge of the glass is half on and half off the lines or letters. Now placing your eye immediately over the glass look down at right angles on it. The lines will appear continuous, whether seen through or without the glass. Now look slantingly, and at once there is a change. The lines are no longer continuous, they seem broken. This is because the rays of light from the lines under the glass to your eye pass obliquely through the glass and are refracted or bent at an angle. The word " refract " is from a Latin word meaning " to break up again."



On the left the lines seen through glass are unbroken because the light rays fall perpendicularly. Seen slantingly as in the other two pictures they appear broken

The picture on this page shows why the lines are no longer continuous. The ray of light is bent by the glass, but your eye imagines that it is still a continuous straight ray and therefore the line under the glass appears to be in a different place from that in which it really is. You get the same effect if you place a spoon in a tumbler of water and then look up at it. Some substances not only refract the light once, but give a double refraction. The mineral known as Iceland spar is such a substance. This is due to the particular crystalline form of the spar.

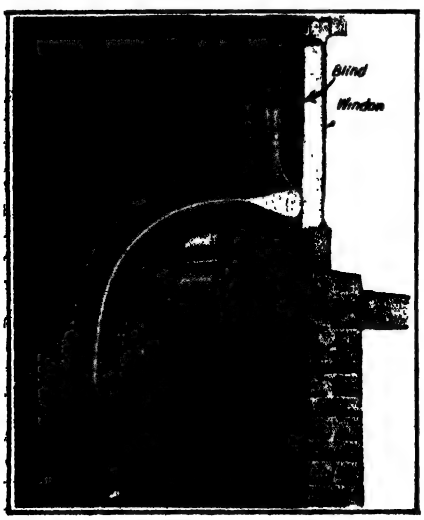
A simple experiment to show how light rays are broken in passing from air to water



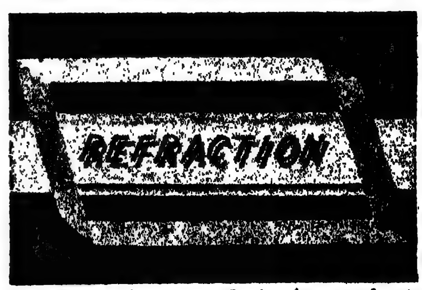
An experiment that shows light travels only in straight lines. If flame and holes are not in a line you cannot see the flame

A stick looks bent in water because the direction of the light rays is changed

Here is an interesting experiment. Take an ordinary bedroom water-bottle and get the glazier to cut in the side a small hole. Fit a cork into the hole and fill the bottle with water. Shut out the light from a room by a dark blind and make a hole in the blind, so that the sun will shine through. In front of this hole place the bottle, as shown, with a pail below. Take out the cork and the water will run out, looking like a curved stream of liquid fire. The light is confined within the stream of water, and is reflected again and again from the inner face of this water tube in very short straight lines.

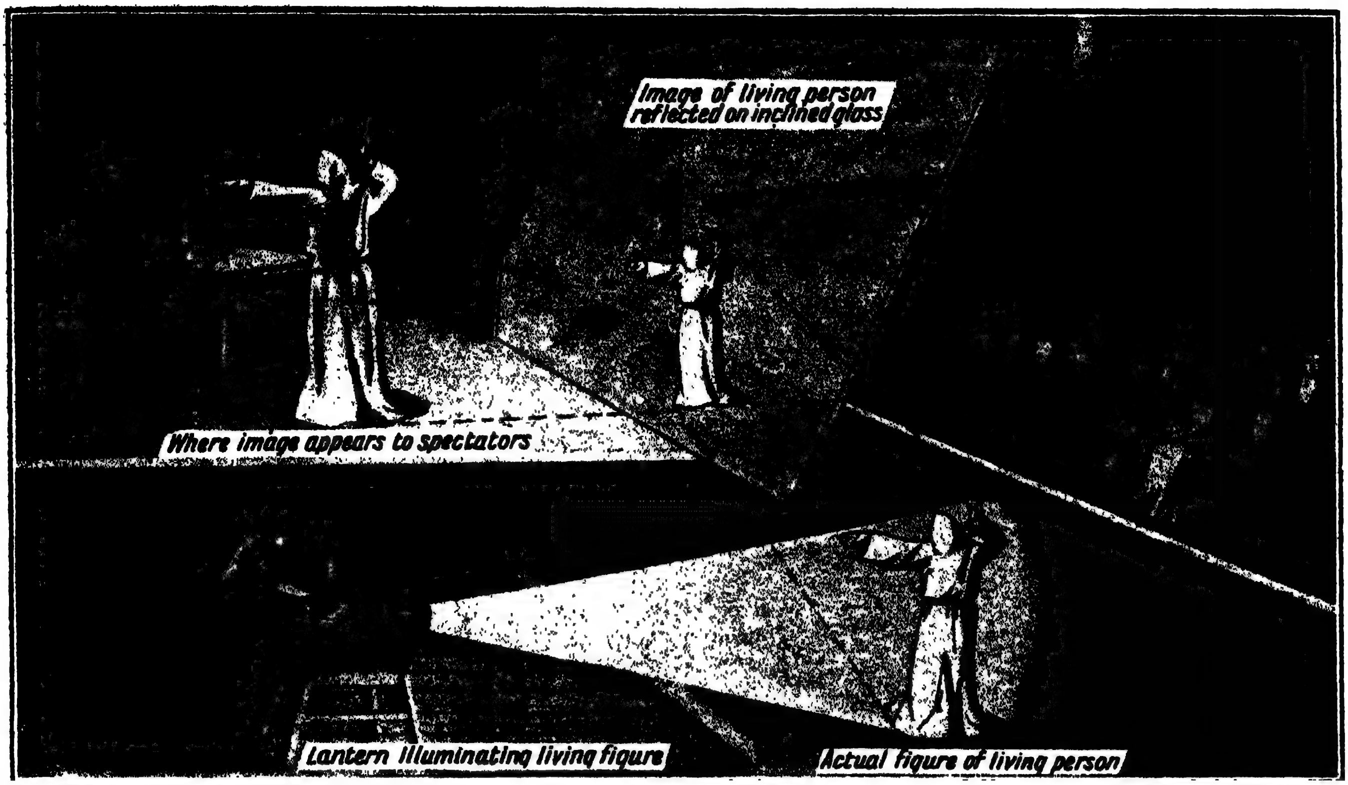


The fountain of light where a beam is constantly being bent in short straight lines



The mineral known as Iceland spar refracts or breaks the light rays twice

TWO CLEVER ILLUSIONS EXPLAINED



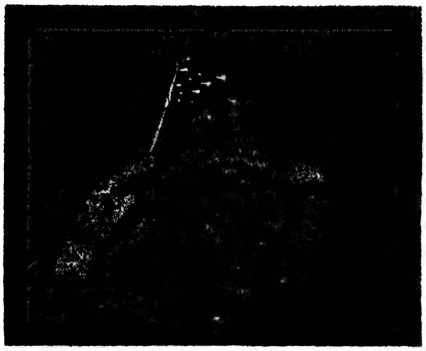
An optical illusion that used to provide a good deal of amusement and entertainment at public gatherings was known as "Pepper's Ghost," being named after the scientist who invented it. The audience looking on the stage saw a ghost appear and move about. Here we see how the illusion was obtained. A real person, dressed as a ghost, below the stage, was strongly illuminated. The front of the stage was open, though the opening was not seen by the audience, and a large sheet of glass was inclined towards the spectators. As the illuminated person moved about below his image was reflected upon the glass. The spectators could not see the glass, as it was transparent, and the reflected image appeared to be moving about actually on the stage. The illusion was perfect

Here is another optical illusion once very popular. Close to a semi-transparent screen on the side opposite to that which the spectators saw was placed another screen with a figure cut out. A light held behind this threw the shadow of the back screen upon the front one and, of course, the cut-out part appeared to the spectators as a bright image of the figure. Now when a number of lights are held near an object not one shadow but as many shadows as there are lights are thrown forward, and when the lights are moved about the shadows also move. In this way by having a cut-out figure of a fairy, and using a number of lights which are moved about a number of images of the fairy are thrown on to the large screen and can be made to move about as though dancing

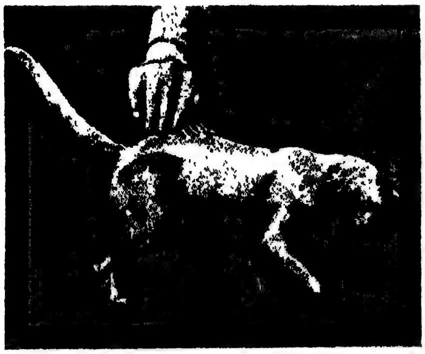
SOME SIMPLE ELECTRICAL EXPERIMENTS

There are many simple electrical experiments which we can perform at home. For instance, on a dry day, when our hair is perfectly dry, if we comb it rapidly with a vulcanite comb we shall probably see a number of electric sparks and hear their crack. In the same way, if we stroke the cat's back rapidly we shall see and hear sparks.

We can generate electricity by rubbing a number of substances. Sealing-wax, for example, if rubbed with flannel, becomes electrified, and if held above our hair will attract it. Similarly a vulcanite comb when rubbed will attract little pieces of paper. It was by rubbing amber that the Ancient Greeks first discovered electricity, and the name "electricity" comes from the Greek word for amber. We can generate electricity by rubbing an amber bead and get a spark by holding it to our ear.



Electric sparks obtained by combing the hair with a vulcanite comb

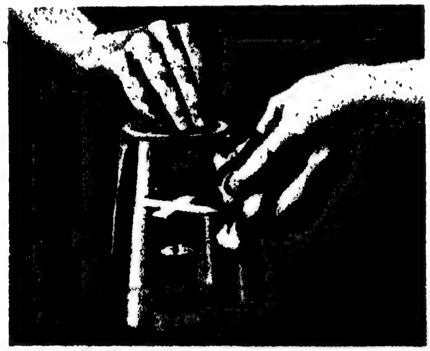


Stroking a cat's fur produces electricity

Sealing-wax rubbed with flannel becomes electrified and raises the hair

Rubbed amber generates electricity

An electrified amber bead will, if held to the ear, cause a spark

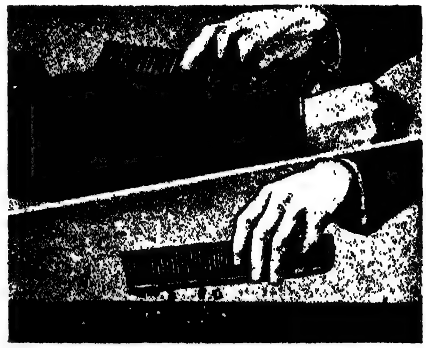


A paper cross can be made to rotate by electrifying a tumbler by rubbing

Brown paper can be electrified by rubbing with the sleeve

The electrified paper held to the nose causes a spark, and the paper can also be attached to the wall without support

Glass rubbed with a silk cloth produces electricity. A clay pipe balanced on the edge of a tumbler can be made to move by bringing near the stem another tumbler electrified by rubbing with silk. It will follow the glass. A sheet of glass supported on books and rubbed with a silk handkerchief will make little paper puppets placed underneath dance up and down. A cross cut out of stiff paper and balanced on the point of a needle stuck in a cork may be made to move mysteriously if a warmed tumbler be placed over it and the glass rubbed outside with silk. By cutting a point on one arm of the cross we can make this turn in any direction by rubbing the glass at that side. We can get an electric spark by rubbing a sheet of brown paper with our sleeve and then holding it to our nose. The electrified paper will also stick to the wall without falling.



A vulcanite comb rubbed on the sleeve becomes electrified and attracts paper

A sheet of glass rubbed with silk will make little paper figures underneath dance

An electrified tumbler will attract a balanced pipe

WONDERS OF THE SKY

WHEN THE SUN IS BLOTTED OUT

A total eclipse of the Sun is one of the most impressive of all natural phenomena. It is not often that there is a chance in the British Isles of seeing a total eclipse, and so British astronomers generally have to go abroad to witness and photograph an eclipse of the Sun. It is at such times that they learn a great deal about the Sun's nature. In these pages we read some interesting facts about what happens when the Sun is blotted out from our view during a total eclipse

It seems strange that we should be able to learn almost as much about the Sun when its face is hidden by the Moon as when its brilliant disc is exposed to our view in all its fiery brilliance. Yet such is the case, for it is only during a total eclipse of the Sun that we are able to see and photograph and study what is known as the Corona, that is the halo of light caused by glowing fiery gases which surround the Sun and send out long and brilliant streamers.

It is rather strange, too, that although solar eclipses have been observed and studied for thousands of years, yet it was only during the eclipse in Europe in 1842 that a scarlet chromosphere or envelope of glowing hydrogen gas was first noticed Since that time, however, a great deal of study has been given to it whenever a total eclipse has occurred, and as a result we now know a very great deal about the nature of the Sun and its surroundings.

Exactly what is an eclipse of the Sun ? In bygone days some queer ideas about its nature have been held. Our Scandinavian forefathers believed that two enormous wolves in the sky pursued the Sun and Moon unceasingly, and that from time to time one or other of the heavenly bodies was overtaken by the wolves, who began to devour it. At such times they made a great deal of noise, shouting and striking metal instruments in order to frighten the wolves away.

A somewhat similar idea was held by the Chinese, and indeed is still held in some parts of their great country. They think that a fierce dragon is trying to swallow the Sun during an eclipse, and they also beat gongs and shriek to drive him off.

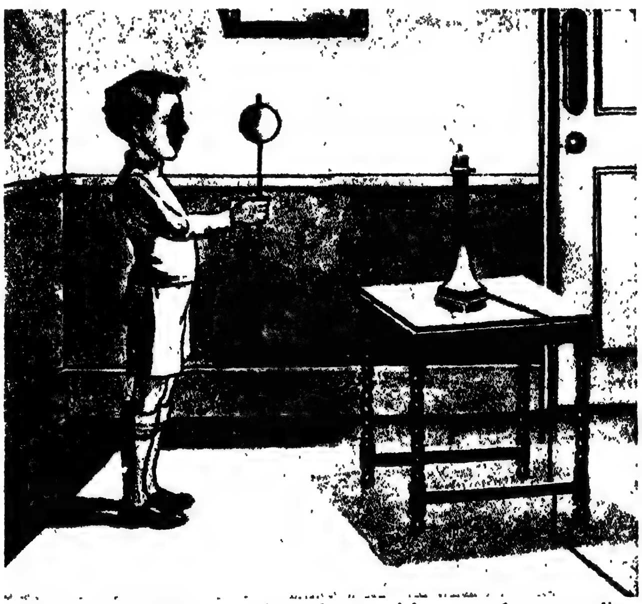
We must not, however, think with pitying contempt of such people and their strange ideas, for even in our own country in the eighteenth century a solar eclipse was believed to have a very harmful effect on terrestrial matters, and a noted English physician had all the wells in his district covered with planking so that the water in them might not be contaminated by the "poisonous mists" which, he declared, arose during an eclipse.

Of course, when people held such beliefs an eclipse was no laughing matter. Millions really feared for their lives and during the period of totality thought the world had come to an end.

In more recent times an eclipse of the Sun led to a strange incident. The proprietor of a diamond mine in Natal, hoping to make his native labourers work more diligently, called them together just before an eclipse and declared that the Sun was about to die, but that it might agree to live again for some years longer if only they presented it with a very large diamond. Thereupon the simple natives dug so well that they actually found a diamond weighing about 45 carats, and carried it with great joy to their cunning employer.

"I think this will persuade the Sun to recover and shine out again," he declared, and sure enough in a few minutes the Sun did actually come out from its obscurity and shine again.

Another incident in Natal during a total eclipse of the Sun did not prove so pleasant for the white employers. The natives came to them and demanded double pay, contending that the day of the eclipse was really two days separated by a night, though a very short one



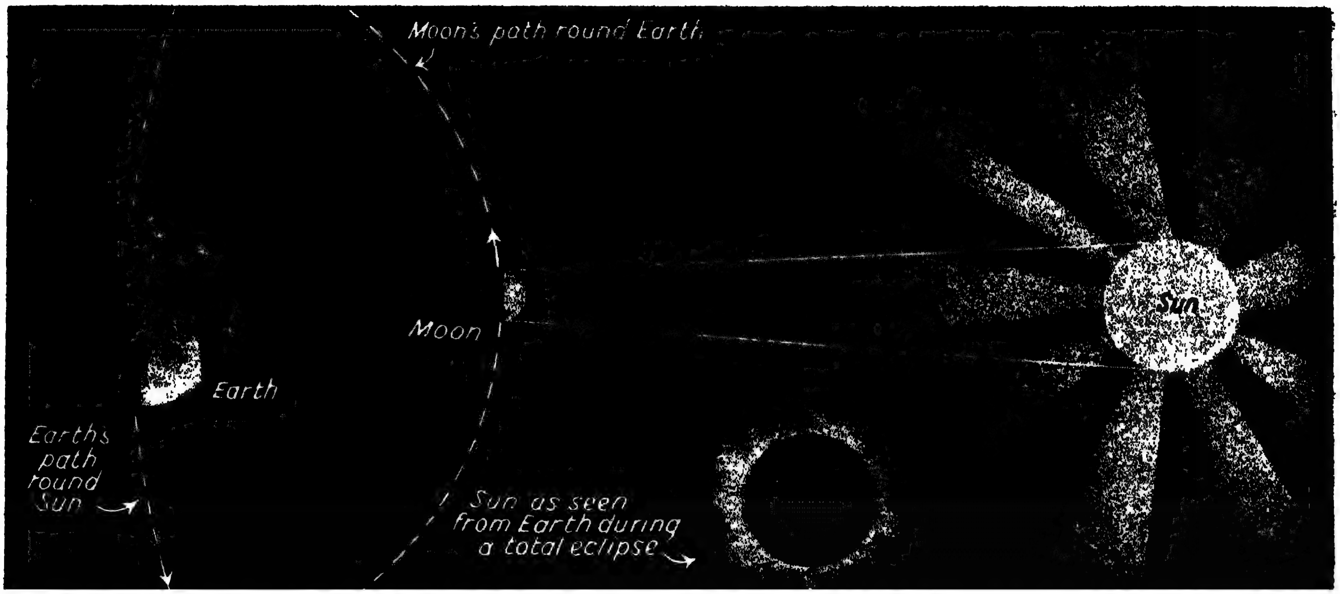
A simple experiment by which a boy or girl can see how an eclipse of the Sun is caused. The boy's head represents the Earth, the orange is the Moon, and the electric lamp is the Sun

We are in no doubt to-day as to what causes an eclipse of the Sun It is simply that the Moon in its journey round the Earth happens to get between us and the Sun, and although it is so much smaller than the Sun, it is nevertheless so much nearer to us that it is able to blot out completely the bright disc of the larger heavenly body Whenever a dark or non-luminous body is illuminated by a luminous body, the dark body throws a shadow to its rear and any non-luminous object which happens to enter the shadow is obscured. This is what happens during an eclipse of the Sun.

The Earth and the Moon have no light of their own, but are illuminated by the Sun, and they both throw a shadow out into space on the side opposite to the Sun. Sometimes the Moon enters the shadow caused by the Earth, and then we have an eclipse of the Moon, as described in another part of this book. Sometimes, however, the Earth enters the Moon's shadow, and then we have an eclipse of the Sun.

By a simple experiment we can see how an eclipse of the Sun occurs. If we stick an orange on a knitting needle to represent the Moon and then stand facing a lamp, the lamp can represent the Sun and our heads the Earth. If now we raise the orange on the needle and bring it round slowly between our face and the light we shall see more and more of the light cut off till at last it is obscured completely by the orange. This is an object lesson of what happens on a large scale when the Moon, coming between the Sun and ourselves, eclipses the Sun.

But the shadow cast by a body passing before a light is of two kinds There is a dark nucleus and a larger but less dark shadow all round it, which is known as the penumbra. This word comes from two Latin words meaning



The Moon is, of course, much smaller than the Sun, but it is able to blot out the Sun's face completely for a short time because it is so much nearer to the Earth than is the Sun. This picture, when compared with the one below, will make clear why some eclipses are total, the Sun's face being completely blotted out, while others are only partial, a small portion of the Sun being still visible. To have a total eclipse, as here, the Moon must be directly between the Sun and the Earth

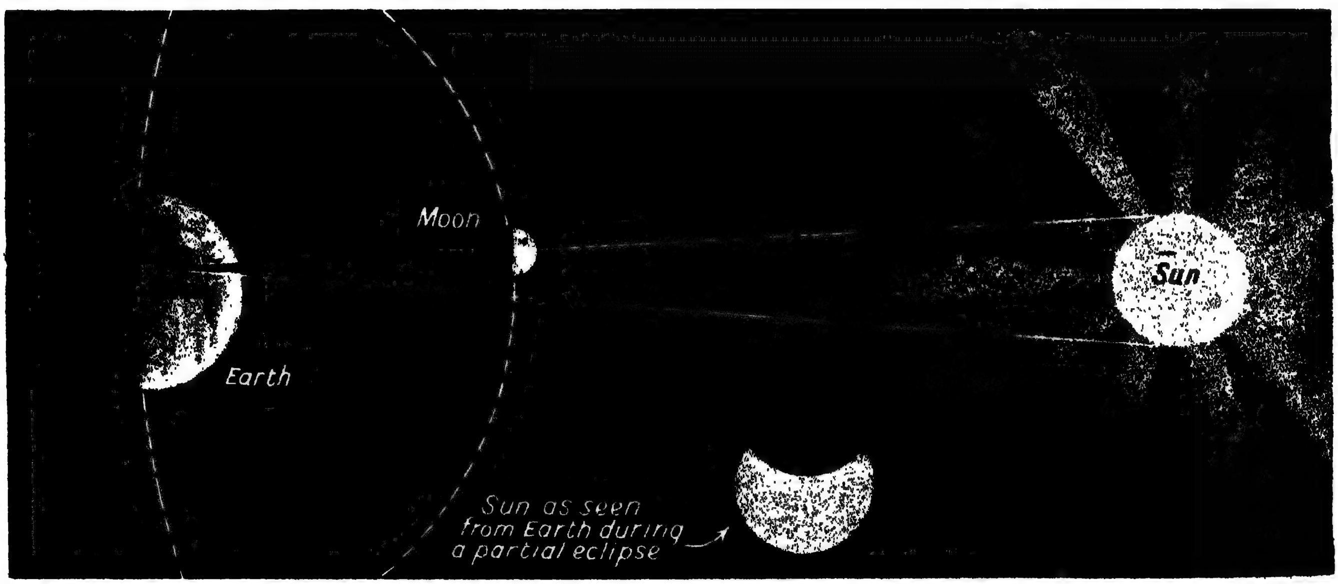
"almost shadow." It is really a partly shaded area all round the dark or total shadow of the opaque body. We can understand this from the picture on page 228.

When the Moon's shadow falls upon the Earth those within the area of the dark shadow see the Sun totally eclipsed, but those within the penumbra would see only a partial eclipse, and the farther away they were from the nucleus or dark shadow the less of the Sun's disc would be obscured. People outside the penumbra would see no eclipse at all

An eclipse of the Sun occurs only when the Earth, the Moon, and the Sun are in a straight line, and this is always at New Moon. As the Moon's orbit round the Earth is an ellipse and not a true circle, its distance from the Earth varies. Sometimes it is 252,970 miles away, and sometimes it is only 221,600 miles distant.

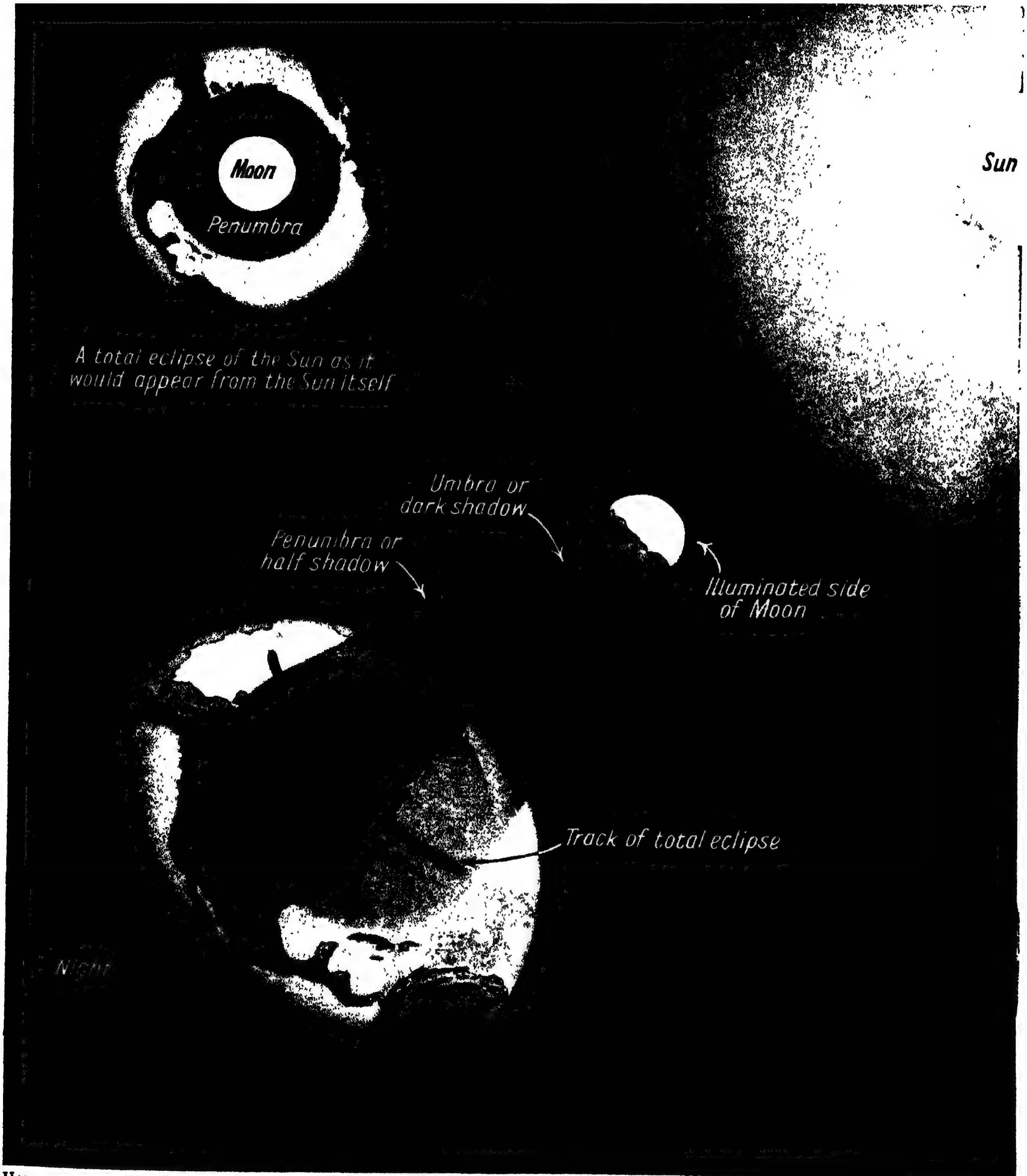
Its distance from the Sun also varies, and so the length of the shadow which it casts varies also. This shadow is sometimes 238,000 miles long, and at other times only 230,000 miles. Sometimes, therefore, the shadow does not reach the Earth at all because the Moon is then at too great a distance from the Earth.

In the last case the eclipse would last rather a long time as the dark shadow cast upon the Earth might be as much as 170 miles wide. If, however, the shadow does not actually touch the Earth then the Moon appears smaller than the Sun which it is hiding, and a small ring of light, part of the Sun's disc, appears round the dark Moon, and then we have what is known as an Annular Eclipse, from the Latin word annulus, meaning a ring. The



Here we see what happens during a partial eclipse of the Sun. The Moon is not directly between the Sun and the Earth, but only partly so, and as a result it shuts off only a portion of the Sun's disc. The result is that that part of the Sun which is not eclipsed still shines upon the Earth. The effect of a partial eclipse is very different indeed from a total eclipse. There is still a third kind of eclipse of the Sun. When the Moon gets directly between the Sun and the Earth at the time when the Moon is at its greatest distance from the Earth, it does not completely blot out the Sun's face, but a narrow ring of light is seen all round the Moon. This is called an annular eclipse of the Sun, from the Latin word "annulus" meaning "a little ring"

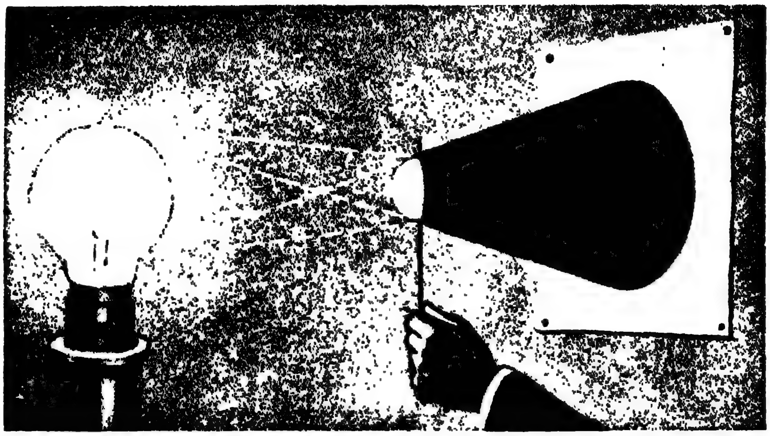
WHAT HAPPENS IN A TOTAL ECLIPSE OF THE SUN



Here we see a total eclipse of the Sun. The Moon in its journey gets between the Sun and the Earth, and when we look up we see what appears to be a black shadow creeping across the Sun's face. Of course, it is not a shadow at all, but actually the Moon itself, which looks black in contrast with the Sun's brilliance. As the Moon continues on its journey and the Earth goes on rotating on its axis, the shadow cast by the Moon on the Earth as it gets in the way of the sunlight travels in a line across the Earth's surface. If the Sun were only a point of light there would be nothing but the dark shadow, but as the Sun has so large a surface there is also a wide zone on the Earth's surface where a partial shadow is caused by part of the Sun's light. It is called the penumbra, or "almost shadow," in contrast to the "umbra" or shadow itself. Along this zone the eclipse is not total but only partial. We can make a penumbra by lighting two candles to represent the two opposite edges of the Sun, placing them fairly near together at equal distances from a wall, and observing the shadow they cast on the wall from an orange held in the way. On either side of the dark shadow there will be a penumbra made by the light of only one candle. In the top left-hand corner we see the Earth during a total eclipes as it would appear from the Sun

same eclipse of the Sun may be total at one part of the Earth's surface and partial at another.

A total eclipse of the Sun is one of the strangest phenomena in all nature. It is a very different thing from a partial eclipse. About ten minutes before the actual totality, darkness begins. Light comes only from the edge of the Sun and has very little blue and violet in it so that it does not seem like sunlight at all. Animals begin to get perplexed, dogs howl, birds go to roost, and even flowers close up. The temperature falls.



A simple home experiment that explains how the dark shadow or umbra and the half-shadow or penumbra in a total eclipse of the Sun are caused. The whole light causes the dark shadow and separate parts of the light the half-shadow

Then suddenly a shadow is seen rushing across the Earth from the distant horizon. But the shadow is not really rushing towards us. We are rushing towards it as the Earth revolves on its axis, so that we are able to see the Earth turning round. The next moment the Earth's disc is completely covered.

Darkness falls with startling rapidity, the stars make their appearance, but the Corona seen round the black disc of the Moon gives a considerable amount of light, equal to three or four times that of the full Moon, and light is also sent into the shadow area by refraction in the surrounding air from places miles away where the Sun is still shining. If, however, the eclipse is one of long duration and lasts six or seven minutes, then everything becomes very much darker.

Men of science can tell us within a few seconds when eclipses of the Sun and Moon will occur in the future for hundreds of years, and when they have occurred in the past. We are able to find the dates of many events in the past by working out when eclipses occurred, for the old historians often mention an eclipse in connection with certain events that happened at the same time, and though their chronology is weak we can correct it by finding out the actual date of the eclipse.

The smallest number of eclipses that can occur in a year is two, and both of these are eclipses of the Sun, but there can be as many as seven, five solar and two lunar, or four solar and three lunar. The most common number of eclipses for one year is four.

Eclipses repeat themselves over a regular interval of 6,585 days, or rather more than 18 years, and that period, which was known even in ancient times, is called the *Saros*, which means a cycle, and was the name given to it by the Chaldeans. During that period there are 29 lunar and 42 solar eclipses.

While the astronomers can predict the actual beginning and ending of an eclipse within a few seconds, they are generally a second or two out because the Earth's period of rotation varies very slightly.

NATURE'S UNDERWATER ELECTRICIANS

FEW fish are stranger than those with the curious property of being able to generate an electric current strong enough to shock anyone touching them. The best known of these is the electric eel found in the muddy waters of the Amazon and Orinoco rivers of South America.

The electric eel (top) and (below) a section through the body showing the organs that generate the shock

Although resembling an eel in appearance, the electric eel is not a bit like the true eel in its internal structure and is, in fact, a kind of fish called a gymnotid. It has a blunt head, a dark brown back, an orange belly, and sometimes grows to a length of seven feet. Only about one eighth of the eel's length is head and body; the rest is taken up by the tail which provides the eel with its battery of electric cells.

Nearly all the tail is filled by a jelly-like mass of cells called electroplates which extend in the form of longitudinal bands. Examination with a microscope reveals that each cell is a small galvanic jar. The cells are all joined to each other and the whole battery is connected to the fish's brain by nerves. The eel is not electrified all the time, but when it is touched a message is flashed to its brain and through its nervous system it promptly switches on its battery. Just how it generates the electric current is not known, but its purpose in doing so is to defend itself when attacked and also to stun the fish upon which it feeds.

A large electric eel can generate an electrical pressure of 250 volts under water or 500 volts if taken out of the water. The reason for the voltage being less under water is that water partly short-circuits an electric current. The voltage produced by the eel out of the water is equal to a current of half an ampere, which is in turn equal to the 100 watts required to run a large electric light bulb. In fact there is an electric eel in the New York Aquarium which sometimes advertises its presence by providing from its own resources the current to light up a neon sign above its tank.

Current produced by the electric eel passes from its head to tail, just as the current from an electric cell or accumulator always passes in one direction. A storage battery will run down and must be recharged, and an electric eel that has been giving many or lengthy shocks uses up its electricity. It then retires to a safe place where it remains until its battery has been recharged. Naturalists have not yet discovered how it does this.

Another of nature's electricians is the electric ray, often found off the coast of Great Britain, and the electric catfish, native to the rivers of Africa.

GAS AND SPARKS THAT MELT HARD STEEL

Scientists have provided the engineer with a gas that cuts the hardest steel as easily as butter, and with an electric spark that melts metals with a heat more than twice as great as the hottest fuel-furnace can produce. In these pages we read about these tools—the oxy-acetylene cutting-torch and the electric-arc furnace.

One hardly thinks of a gas cutting the toughest steel as easily as a knife cuts butter; but that is exactly what happens when an oxy-acetylene torch is used to break up scrap metal.

When water is dripped on to calcium carbide, heat is absorbed from the surrounding air or from the wall of the vessel in which the carbide and water are contained. The carbide and water then combine to produce acetylene gas and calcium hydroxide, the latter being the chemist's name for slaked lime.

Burning Carbon

Acetylene is a colourless gas with a smell like that of garlic, and contains an exceptionally large number of carbon particles. When the gas is lit, the carbon particles are set free, causing the flame to glow brilliantly, but they do not burn up immediately to give great heat because there is not enough air present.

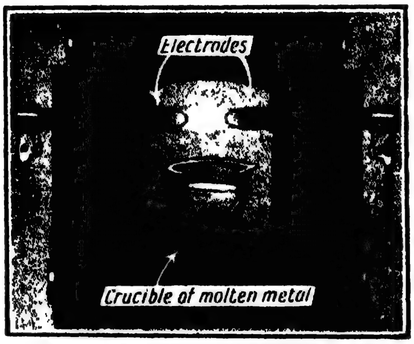
If a jet of oxygen (air) is blown against an acetylene flame, the flame will lose its brilliance and glow with an intense heat; which is the same thing as blowing on a burning stick or piece of coal to make it glow more hotly. This is the principle of the oxy-acetylene cutting-torch.

Heat-Energy Released

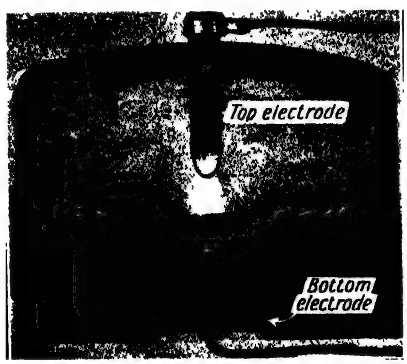
When acetylene breaks up again, that is, is converted back into carbon and hydrogen (which is what happens in the oxy-acetylene torch), the heat energy which was absorbed into the gas when the water dripped on to the calcium carbide is given out once more in the gas flame. This heat, added to that produced by blowing oxygen against the glowing carbon particles in the burning gas, is the cause of the very high temperature of the acetylene flame coming from the nozzle of the torch

The more oxygen, up to certain limits, blown against the flame, the fiercer will be its heat. Gas is supplied to the torch from two cylinders, one containing acetylene and the other oxygen, and the mixing of these is regulated by a tap on the torch.

The acetylene burner is in the form of a ring and, as the gas burns, a jet of oxygen is introduced into the middle of the ring, raising the temperature of the flame from about 2,476 degrees Centigrade—the temperature at which acetylene burns in air—to 3,315 degrees Centigrade. This intense flame makes such a clean cut that rings and other shapes can be carved out quickly and the surface of the cut kept quite smooth.



A simple form of electric arc furnace. The current passes between the electrodes, giving a temperature of about 3,870 degrees Centigrade to melt the metal



Another type of electric arc furnace. Here the current passes between the top electrode and the bottom electrode, causing intense heat and melting the metal or ore that has been placed in the furnace

The oxy-acetylene torch is easily handled, and can be directed with great accuracy; but, owing to the intense light of the flame, the workman using the torch has to wear dark goggles, and these must also be provided with side-pieces to protect his eyes from the sparks or fragments of molten metal that shoot up from the iron or steel when it is being cut. In fact, to watch a man using the oxy-acetylene torch is like watching a miniature firework display.

Breaking Up the Battleships

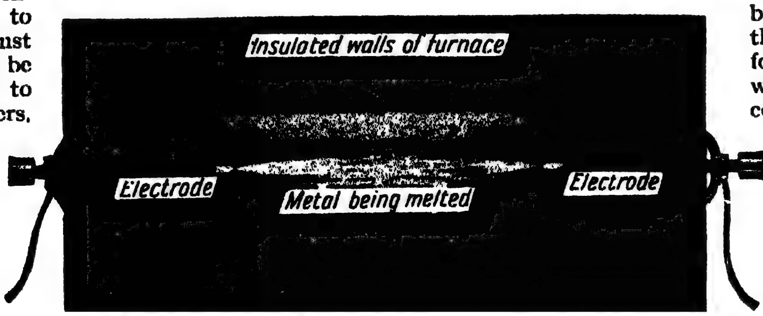
The size of the flame is regulated according to the thickness of the metal that has to be cut. This wonderful tool is invaluable when iron and steel ships have to be broken up; as, for example, when breaking up obsolete warships or disused tram and railway lines. In the old days the breaking up of a metal vessel was a long and tedious business; now it is done quite easily, and the steel plates or girders can be cut up into pieces of any convenient size that may be desired.

But the oxy-acetylene torch is not useful only for destructive purposes; it is used in the construction of ships, bridges, machinery and so on. Not only is it used for piercing the holes in metal plates much more rapidly and cheaply than by the old method of drilling them, but it is used for welding metal joints instead of bolting the parts together. The intensely hot flame melts the two surfaces to be joined, so that they fuse together, forming one piece of metal and providing a join nearly as strong as would have been made had they been bolted or riveted.

The Flame that Burns Under Water

As we see in another part of this book, the torch can be used by divers under water. In that case the water has to be forced away from the point where the flame comes in contact with the metal, and this is done by arranging an air blast all round the oxy-acetylene jet, so that the pressure of the air will drive off the water from the flame.

Another use of acetylene gas is as the source of light in bicycle and other portable lamps.



A resistance furnace in which electric energy is converted into heat of about 3,870 degrees Centigrade by the resistance of the material it passes through

Water, as we know, is made up of the two gases, oxygen and hydrogen, and when it drips upon the carbide some of the hydrogen seizes on the carbon in the carbide, combines with it and forms acetylene gas, which consists of carbon and hydrogen. The greyish material left behind in the carbide chamber is slaked lime, consisting of calcium, oxygen and hydrogen.

Acetylene gas in the bicycle lamp is quite harmless, provided the nozzle is kept clean and open, so that the gas can escape as it is formed by the dropping of the water on the carbide. When compressed, however, the gas is very liable to explode.

The electric arc can be used in the same way as the oxy-acetylene torch for cutting metal, and, as already explained, its heat is even greater; but it is not so useful, because it cannot be controlled so well and the cut it makes is not so smooth and even as in the case of the gas torch.

But electric furnaces are coming more and more into use for the melting of metals and the smelting of ores. The substance to be melted is placed in or near the gap across which the electricity must pass, and the furnace is very useful in places where fuel is difficult to obtain, but there is plenty of water-power.

Current for the furnace can be generated by means of water turbines, and thus the heat of the Sun is really used indirectly; for it is the Sun's heat which draws up the water from the sea so that it can fall as rain, thereby giving the water-power necessary to produce the electric arc in the furnace.

It is interesting to know that the oxy-acetylene torch is dependent upon the electric furnace, for it is by means of this latter device that calcium-carbide, used in the making of acetylene, is produced.

Coke and lime, broken into small pieces about the size of walnuts, are placed in huge electrical furnaces, and when a powerful current is turned on and the great arc produces enormous heat, the calcium of the lime combines with some of the carbon of the coke and forms calcium-carbide, while the oxygen of the lime combines with the rest of the carbon, forming carbon-monoxide gas. Were it not for this inexpensive process of producing calcium-carbide, we should not be able to make our acetylene gas so cheaply.

The manufacture of calcium-carbide was, indeed, one of the first industries to make use of the electric furnace. Large furnaces of the arc type are used with electrodes in the form of huge blocks of carbon built into massive foundations. White-hot carbide at the enormous temperature of 3,500° Centigrade is drawn off at the bottom of the furnace, and after cooling is crushed, sorted into sizes, and sent to different parts for use. Huge quantities are made in Norway, where the current for electricity is obtained from water-power. Hundreds of thousands of tons of carbide are turned out in this way, and many other countries make it. Indeed, the carbide industry is now one of the great industries of the world, thanks to the electric furnace.

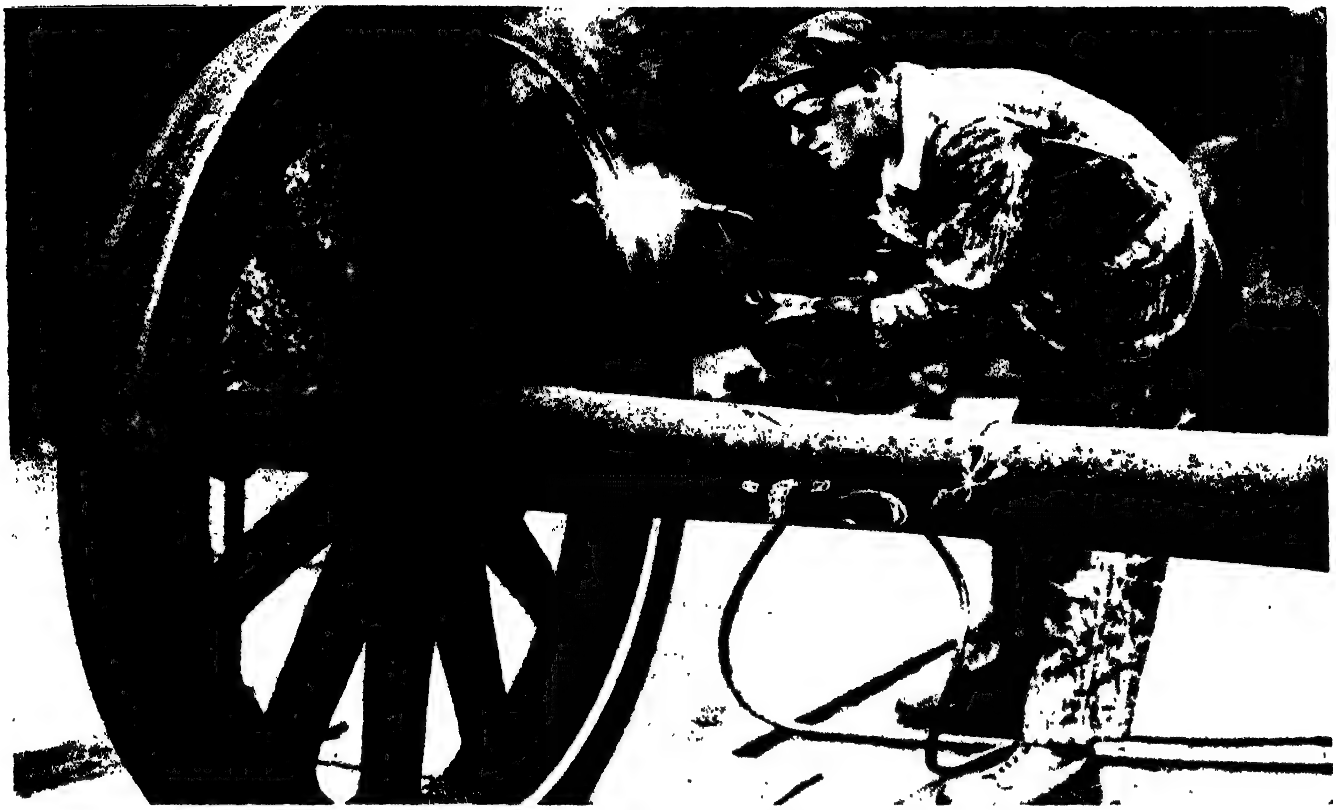
There are other types of electric furnace beside those which produce an arc. One of the simplest forms is known as the resistance type of furnace, in which heat is produced by passing a powerful current of electricity through a conductor of such a resistance as to produce the required amount of heat.

A huge electric furnace in a large steel works at Sheffield. A furnace of this type is capable of handling up to twenty tons of molten metal at one melt, and the electric current consumed in the process is sufficient to light a small town. In the picture stainless steel is being poured from the furnace. Stainless steel manufacture is an industry in which England leads the world to-day

An important use of the electric resistance furnace is the making of steel. Much of this electrically made steel is produced by current from the Niagara generating stations. The electric furnace is also extremely useful in extracting rare and refractory metals, which were formerly unknown, from the ores in which they exist. Among such metals are chromium, tungsten, titanium, and molybdenum. When small portions of these metals are added to steel it becomes enormously stronger and harder.

These are only a few of the ways in which the tremendous heat of the electric furnace is utilised in industry to-day.

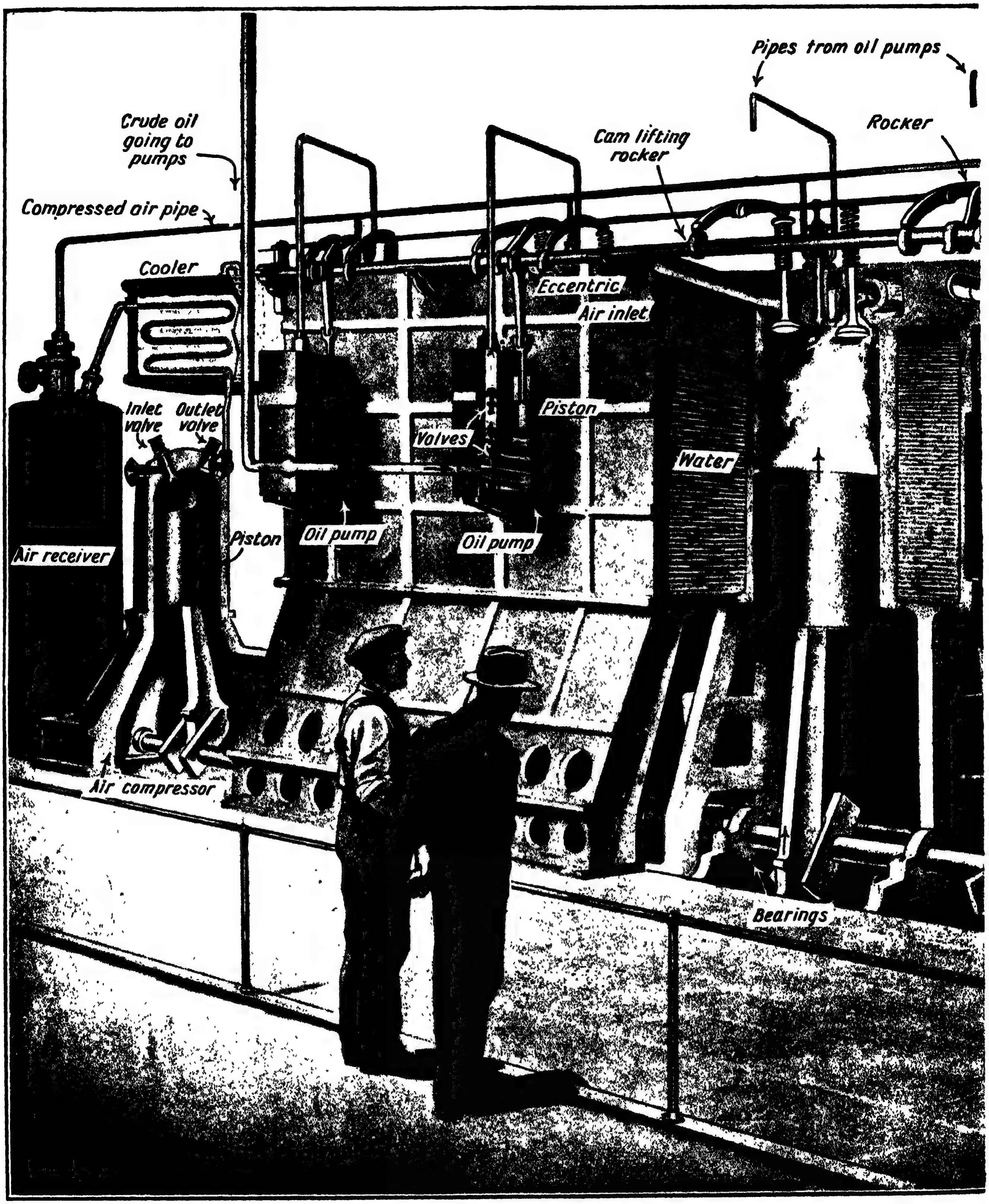
USING A FLAME HALF AS HOT AS THE SUN



By burning acetylene gas with oxygen gas playing round it, we can get a heat equal to 6,000 degrees Fah., and this will cut through metal very rapidly. Here we see a workman cutting away the old tread of a railway engine wheel, so that a new one can be fitted on. It is interesting to know that while the oxy-acetylene flame can be used for cutting metal, it can also be used for welding or uniting metals

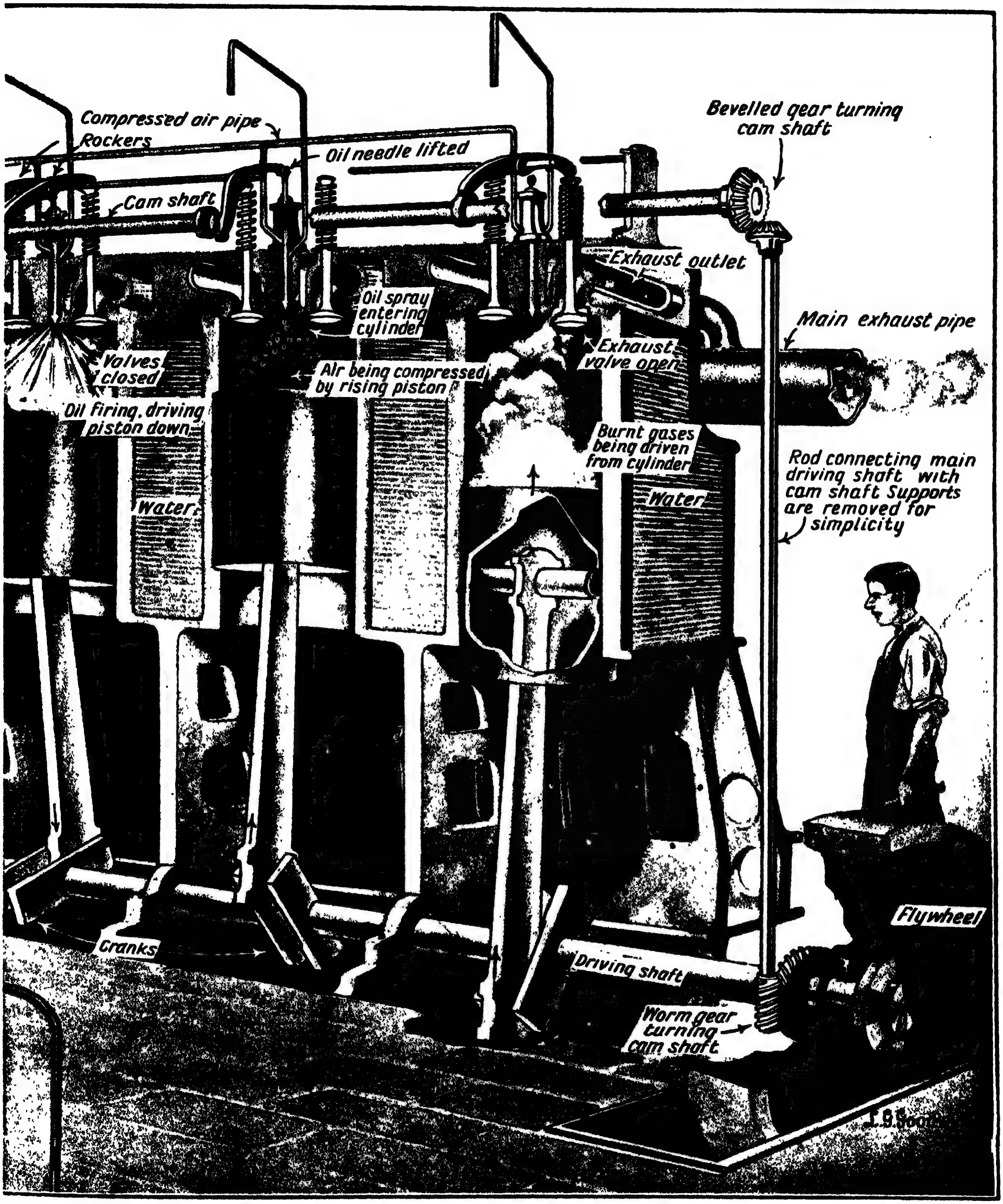
The amount of time and expense saved by the use of the oxy-acetylene torch for cutting up metal such as old ships, boilers and engines is enormous. In this picture a workman with an oxy-acetylene jet is cutting through a steel forging six inches thick, almost as though it were cheese. The cylinders of oxygen and acetylene are shown at the back. The Sun's surface heat is about 11,000 degrees Fah.

HOW A DIESEL ENGINE WORKS BY



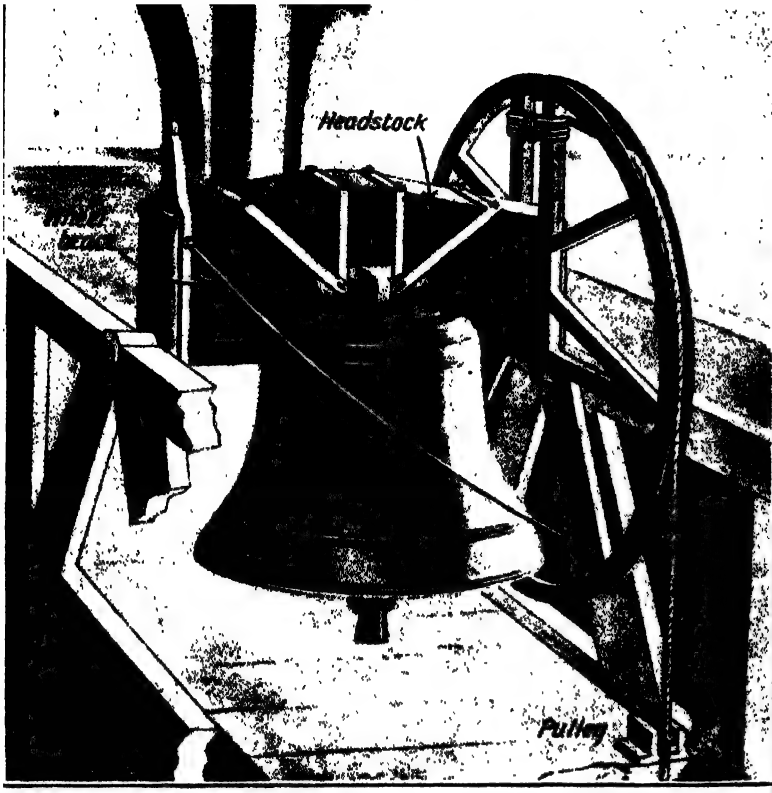
This picture, running across two pages, shows a Diesel engine and how it works. A Diesel engine is an internal combustion engine in which crude oil is used. Many ships are now fitted with Diesel engines. On the left can be seen an air compressor. It is worked by the driving shaft. Air is drawn in, and compressed when the piston goes up. This makes the air hot. It passes out through a coil, where it is cooled by cold water, and goes into an air receiver ready for use. The Diesel engine shown has six cylinders, and to start it the compressed air is let into the cylinders and drives the pistons. Once it has begun to move the engine works in the following way : In each cylinder in turn as the piston goes down ordinary air enters through an inlet above, a valve opening for this purpose. Then as the rotating shaft with its cranks drives the piston up once more, this air is compressed and gets hot. At the same time, just before the

USING CRUDE OIL FIRED BY HOT AIR

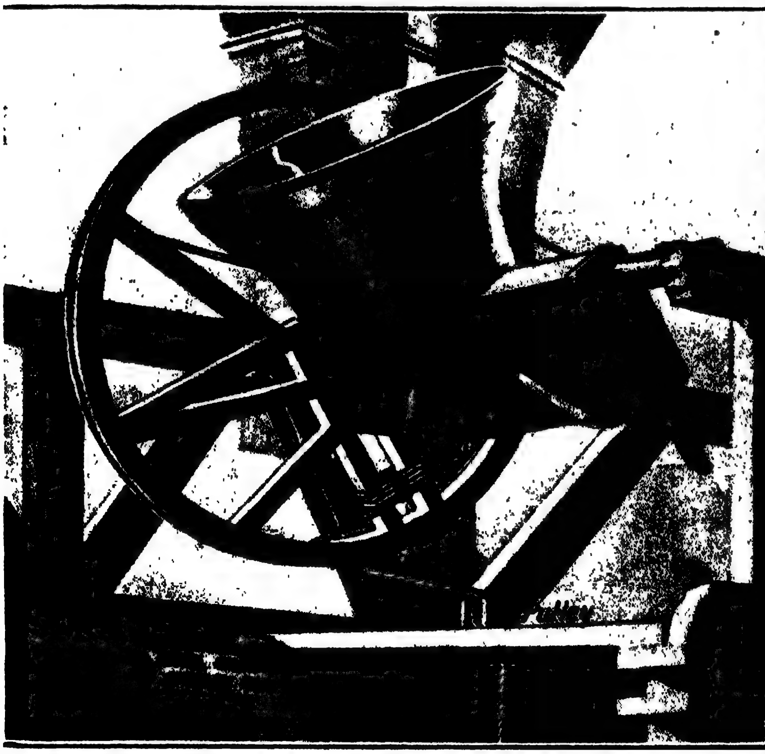


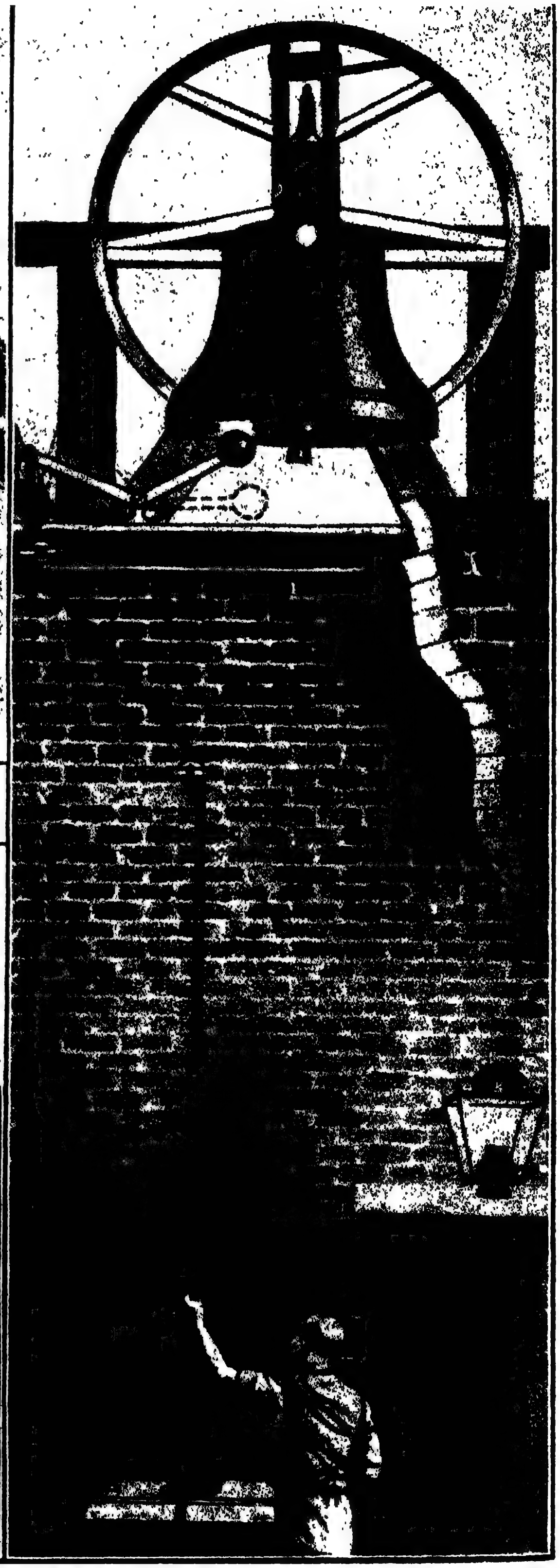
piston reaches the top of its journey, a fuel valve opens and a small quantity of heavy oil is sprayed into the cylinder by the compressed air from the receiver. At once the heat of the air in the cylinder, which is compressed by the rising piston, fires the oil, and the burnt gases expand until just before the end of the stroke, when an exhaust valve opens and these gases pass out. As soon as they have left the cylinder the exhaust valve shuts, and the air valve opens drawing in another charge of outside air, when the whole process is repeated. The same process is always happening in two of the cylinders, the cylinders working in pairs. Four of the cylinders are here shown uncovered, the other two being at the left of the engine. The fly-wheel on the right keeps the shaft rotating steadily. The valves are worked by cams on a cam shaft. The fuel oil is supplied from a large tank above the engine and the engine is kept cool by cold water

HOW A BIG BELL IS RUNG AND CHIMED



When a church bell is out of use it hangs mouth downwards, but for ringing it is turned mouth uppermost. This is called "setting" the bell. The bell must swing when struck with the clapper or it may crack





The ringing of a church bell needs skill and experience. The bell is fixed to a block of wood called a headstock. On one side is a large grooved wheel, to which the rope is attached, and this wheel is connected with the other side of the headstock by a brace. When the hanging bell is to be rung the ringer pulls the rope, which works over a pulley to avoid friction, and turns the bell upside down. The rope is then pulled and at once the wheel begins to turn, the rope coiling itself round three-quarters of the circumference. At each pull the bell is made to describe a full circle. Then when it reaches the upright position it makes a full circle in the other direction, the swing being done not so much by the pull of the ringer as by the weight of the bell. The bell must never be swung right over as this damages the frame. The bell is not turned upside down for chiming, but is often struck by an outside hammer, as shown on the right

THE SPIDER AND ITS MARVELLOUS SNARE

There are many people who have a great dislike of spiders. They are horrified when they see one, but really this is very foolish, for not only are spiders perfectly harmless to human beings, but they are extremely interesting creatures and well worth careful examination and study. So far from our British spiders wanting to do any harm to a human being, their only desire when they see one is to escape as fast and as far as possible. In these pages we read many very interesting things about some of the spiders that live in Great Britain

Some people talk of spiders as insects, but the spider is not an insect at all; it belongs to quite a different family. Insects in their mature stage have three divisions of the body plainly marked, a head, a thorax, and an abdomen, but in the spiders the head and thorax appear joined together, and their bodies present only two obvious divisions.

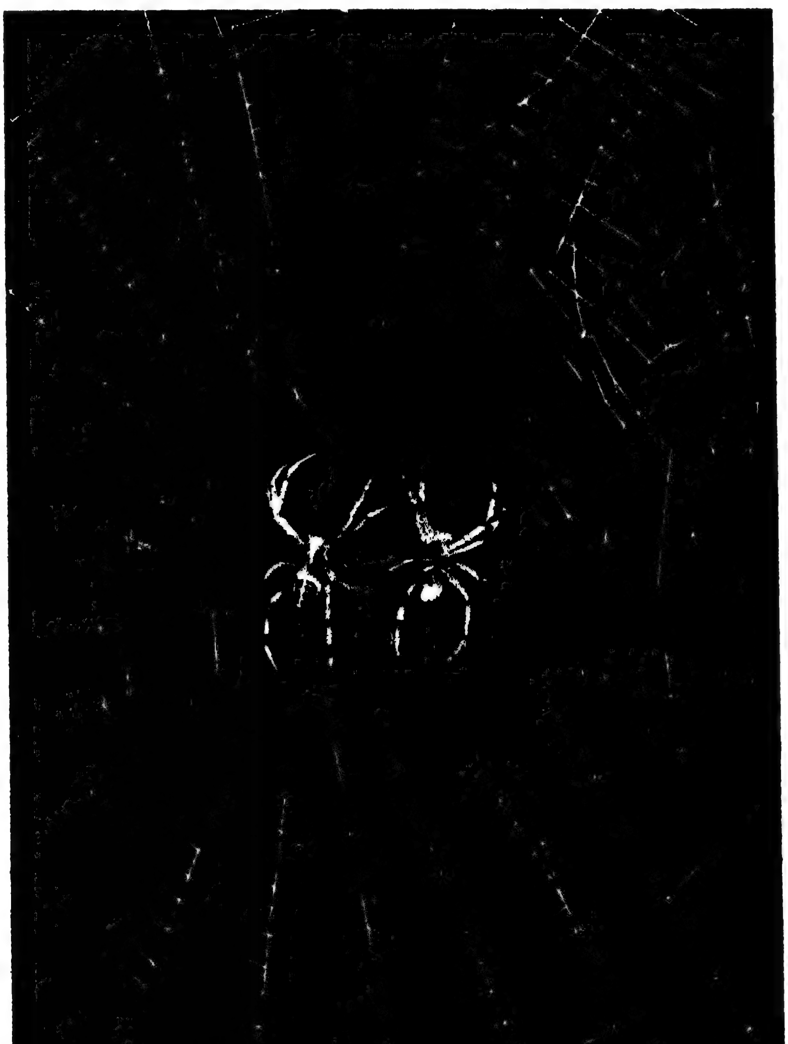
An even simpler way of knowing that a spider is not an insect is by examining its legs. All insects in their mature state have six legs, but spiders have eight. Spiders, together with scorpions and mites, belong to a family or class known as Arachnids, a name that comes from the Greek word for a spider's web

Foes of the Insects

So far from being members of the insect family, spiders are the implacable foes of all insects, with whom they are always waging cruel and bitter warfare. They set traps to catch them, they pounce upon them out of ambush, they bind them in bonds which make them helpless, they drug them with a venomous fluid, and, having killed their victims, they feed upon their blood and finally throw away their carcasses.

Spiders are found all over the world except in the sea, and plenty of different kinds or species are native to Great Britain. Even the house spider, whose cobwebs are so detested by the housewife and maidservant, is a creature well worth studying. It must have a very bad time, for no sooner is its web seen than it is swept away and the poor spider has to start all over again.

These webs of house spiders are not so beautiful to look at as the dainty geometrical webs of the garden spider, but they are very strong, and they have to be, for often they must sustain the weight of much dust, together with fragments of mortar and other odds and ends that fall upon them. In order that they may be equal to the strain the spider frequently strengthens the threads from time to time with several layers of fresh thread



This spider spun its web across a mirror and then, seeing its reflection in the glass, thought it was facing an enemy and tried to fight it

The cobweb in the corner of the room looks a tangled, aimless mass, but it really consists of a closely woven tube in which the male and female spider live happily together, the female laying her eggs in cocoons, several being placed together in a bag of fine silk. Then at the end of the tube is a flat net, spread out for the catching of insects.

When a fly alights on the tangled skein it is caught by the feet and, as it struggles, soon becomes entangled in the meshes. Directly it begins to struggle threads running from the snare to the den make its presence known, and the spider hurries out to seize and feed upon its victim.

Setting the Net

But the garden spider is a still more interesting creature to study. It is well worth while having the patience to watch it right through the time it is making a web. This work it does with great skill.

The spider first of all sends out a line of thread from her spinneret—the apparatus at the rear of the body from which the thread comes—and this is allowed to float in the air till it catches somewhere on a branch or leaf. The spider pulls the thread to see that it has caught securely and then fastens the other end to some firm object.

She again tests it, and then runs along the thread to the far end. As she does so she strengthens the line with another thread. Then she drops and fastens a line from the first one to some branch or leaf below and climbs up to fasten still another.

Soon she has a framework on which she can begin to weave. Then she drops a line from top to bottom of this frame, and from the centre of that line runs out, with great accuracy and skill, a number of radii Having completed these she goes to the centre and plucks at each line to test it.

Finding everything right, she begins then to spin a spiral connecting it with the radial lines at each point of crossing. Having completed one spiral she starts another, till at last the spiral lines are very close together They are not the same as the rest of the web, but have a stouter appearance. This is due to the fact that the transverse threads are coated with a sticky substance, so that any insect which is unfortunate enough to fly or crawl into the web is held

The spiral thread near the centre of the web is not covered with this sticky matter, so that the spider can rest there without fear of being caught in her own toils. Further, it is believed that the spider exudes a substance which counteracts the sticky material, so that she never adheres to the web but can travel over its threads safely and easily

If the spiral threads be looked at through a magnifying glass the sticky material can be seen in the form of little globules. These soon dry in the air and the spider is constantly renewing the spiral threads so that they may remain sticky The old thread which has become dry is eaten by the spider. The weaving of the whole web takes less than an hour.

Having completed her work, the spider retires to some hidden place under a leaf, and watches for prey Soon an unhappy fly strikes the web and is caught. The more it struggles to get free the more it sticks to the threads, and in a moment the vibrating threads have indicated to the spider that she has a victim.

She hurries down, bites the fly with her poison fangs, so that it becomes numb, and drags it off to her lair to suck the juices from it.

While she is at her meal the web again begins to vibrate, and leaving the first fly, she hurries off to find another one caught. As she will not want this at once, after injecting the poison, she winds it round and round with silken thread, turning it over and over with her feet as she does so. Then she leaves the doped and bound prisoner hanging in the web, while she goes back to continue her meal off the first fly. She then goes down for the other, unless she is already satisfied. If a wasp or bee is caught in the web the spider sometimes binds it round and round with silk, trying to evade the sting, but more often than not she cuts her web and releases the prisoner.

Gossamer spiders, here shown enlarged, floating through the air

The male spiders also make similar webs, but these creatures are smaller than the females. They go courting, and when the lady spider is tired of her mate she will often kill him, that is unless he moves away very quickly.

After a time the female spider lays a number of eggs in a little silk bag which she weaves for the purpose, and from these are hatched in late summer the baby spiders, which break a hole in the silk bag and escape.

We may often see hanging by a thread from a web what appears to be a cherry stone. If we go near and touch it, all at once the lump breaks up and we find that it was not a real cherry stone at all, but some hundreds of little garden spiders clinging tightly together. They run away in all directions, but if we keep quite still they will gradually return.

As the baby spider grows its skin becomes too small for it, so it splits, and the creature comes out with a new soft skin round its body But this, however, soon hardens, and later on the spider, continuing to grow, needs another new suit, and so the moult is repeated. It must be useful for the parent spiders that their children can make their own clothes as they need them.

The thread which the spider uses for its web is really a fluid when it comes from the spinneret, but it soon dries when it is exposed to the air. It is very strong, and attempts have been made to use it for commercial purposes, but unfortunately when large numbers of spiders were kept together to produce web, they ate one another.

The filmy gossamer which we see floating in the air and covering the bushes in autumn is the product of a tiny spider known popularly as the gossamer spider. It is a very small creature, and on a warm sunny day it will spin a thread or two on a leaf or branch, and then, holding tight and raising its abdomen, send out streamers in the breeze. As soon as two or three loose threads have been spun the little spider lets go its hold and allows the gossamer to carry it in the breeze across the country. Often it travels for many miles in this way, and sometimes these gossamer spiders descend on ships far out at sea.

THE GREAT WONDER OF THE BREAKFAST EGG

We eat our breakfast egg without thinking that there is anything very wonderful about it, but in reality an egg is one of the most marvellous things in the world.

In it is the embryo or germ of life which in proper conditions will develop into a living creature like its parent. Round the embryo is a golden-yellow fluid which we call the yolk. It is enclosed in a thin elastic membrane which enables it to keep its spherical shape, and at each end is a little twisted cord of white known as a balancer. The balancers support the yolk as in a hammock, so that if the egg gets a jerk the yolk is not damaged, and they also hold the yolk in such a way that the embryo or living part of the egg always lies nearest to the hen's body when she is sitting on the egg. Thus it keeps warm.

What a hen's egg is like inside

Then round the yolk there is the white of the egg, a transparent fluid with an air space between it and the membrane lining the hard shell. This shell of chalky material has small pores through which the chicken can obtain oxygen and pass out the carbon dioxide gas that it forms.

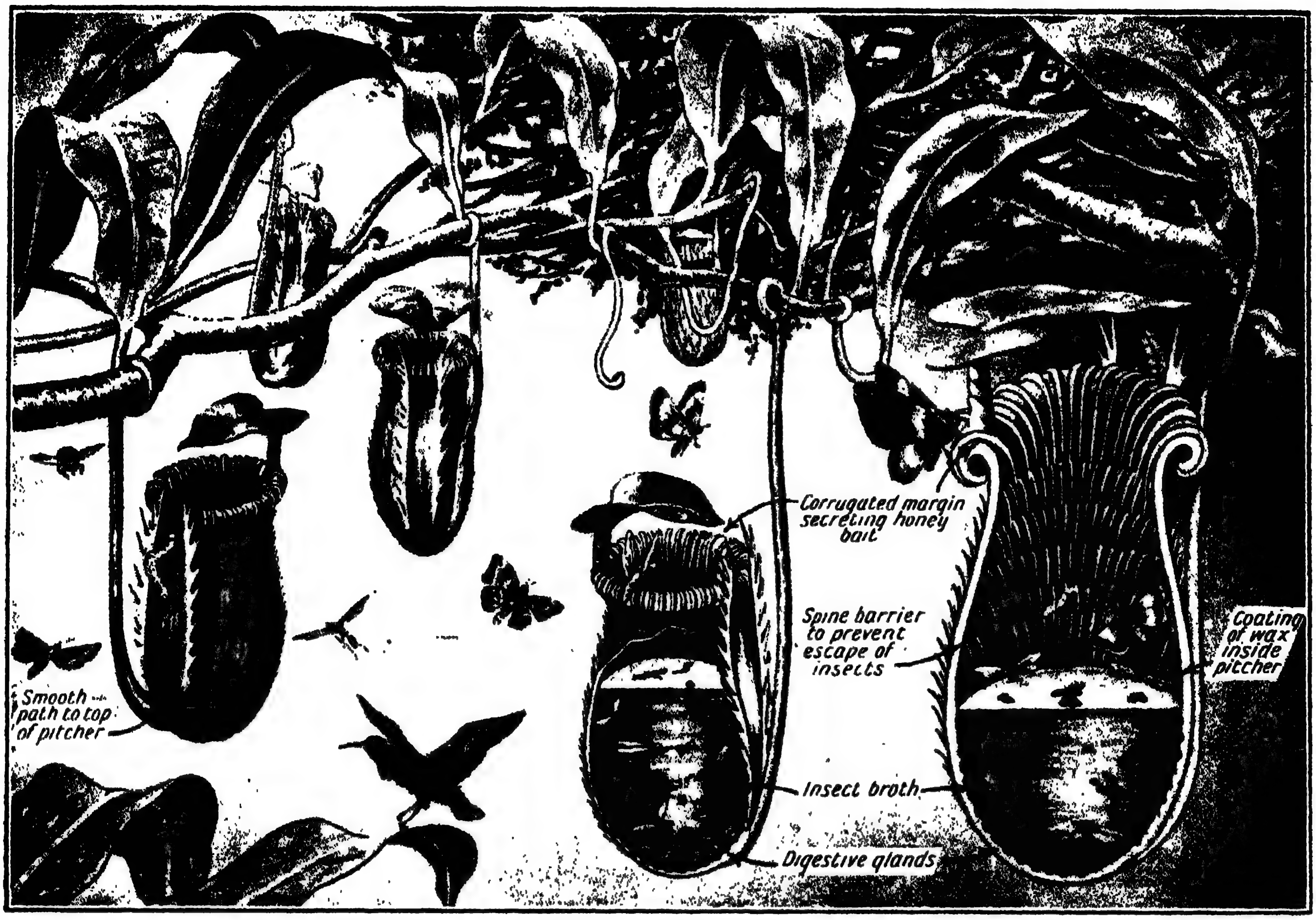
As the chicken develops it absorbs the yolk and the white as food.

THE SPIDER'S BEAUTIFUL SILKEN WEB

The spider is a skilful artificer, and spins a wonderful web like that shown here. It was completed in forty minutes from the time the creature started. The threads of silk are about a hundred times finer than human hair, but they are said to be stronger than steel of the same dimensions. They will support a great weight and resist a strong wind

Spiders are able to cross a stream, and this they do by supporting themselves on a branch or plant and paying out web, allowing it to float across the stream. When it has caught somewhere on the other side the spider can then travel across the line, but it always tests the line before attempting to make a journey over it. The web material is fluid when it emerges from the spider's spinnerets, but it hardens in the atmosphere. Although it is sticky, the spider has some way of avoiding being caught in its own web

A PLANT'S DEATH-TRAP FOR INSECTS



The Pitcher Plant, or nepenthes, which grows in the Tropics, draws its nourishment largely from insects, and has a very clever death-trap in which to catch them. The plant grows in marshy forests, and each lance-shaped leaf is extended at the end into a coiling tendril which reaches out till it finds support on the branches of some other plant. Having wound round the support, the end grows into the form of a pitcher with a cover to keep out the rain. In some species the pitcher is more than a foot long. Inside, the pitcher has a coating of wax, and round a corrugated margin at the top is secreted a honey-like substance. This acts as a bait to insects, and while they are eating it they slip on the shiny wax and fall into the pitcher, which holds water. The insects try to fly or crawl out, but the sides are slippery and, further, are provided with spines pointing downwards, so that the pitcher is a kind of lobster-trap and the insects, once inside, cannot get out. Finally, the insects are drowned, and the water, which has in it certain ferments provided by digestive glands, becomes a sort of insect broth and the plant is able to absorb the proteids from this and nourish itself. Small birds visit the pitcher plant for insects

WHY WE COOK POTATOES BEFORE EATING THEM

Taking it all round, animal foods are less easily digested when cooked than when raw. Raw eggs, for example, can be digested much more easily than boiled or fried eggs. This is because the protein matter in the animal food coagulates during cooking. But it is different with vegetables, for they are very poor in proteids. On the other hand, they are rich in carbohydrates, principally starch.

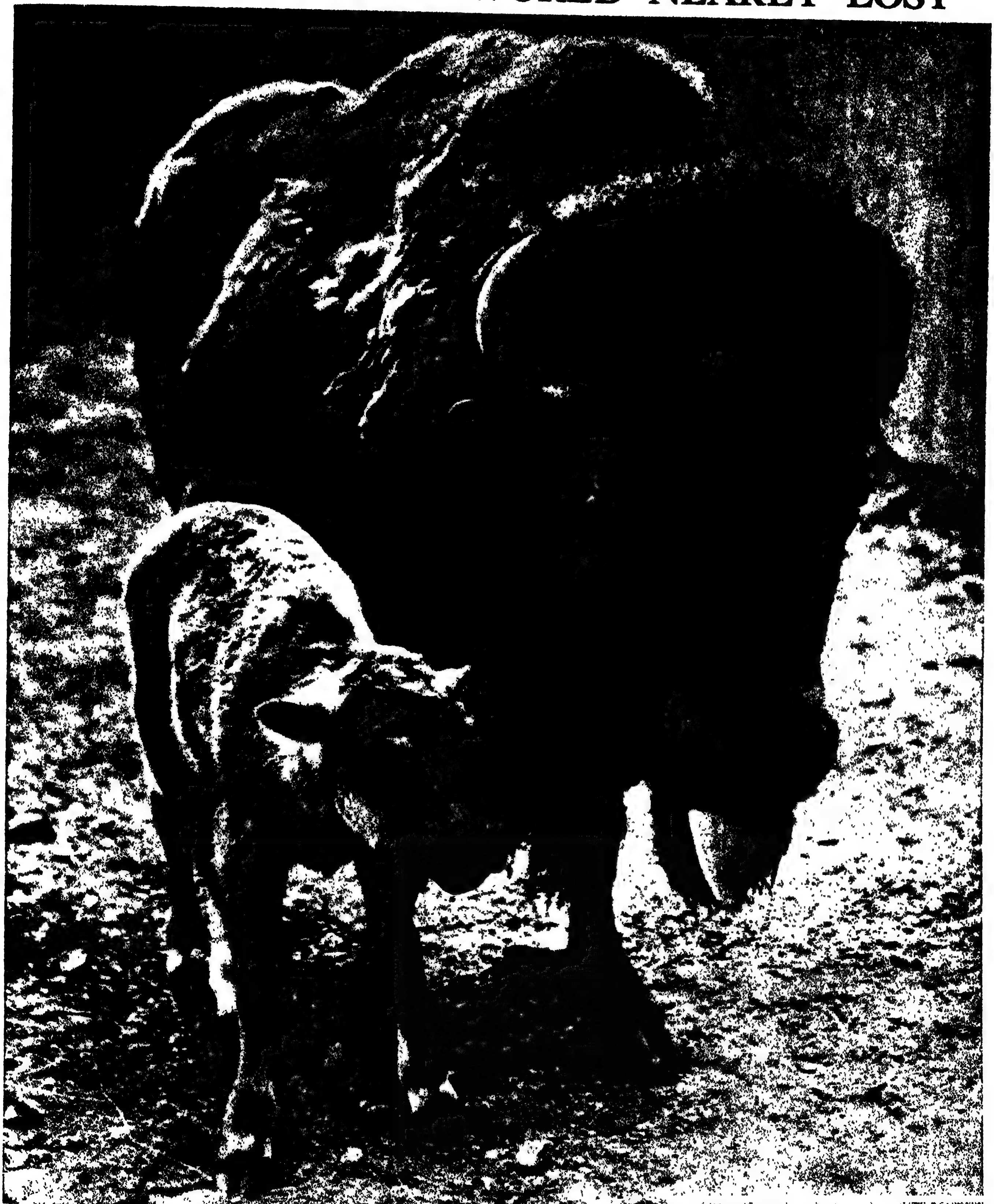
This starch is enclosed in cells with thick and tough walls which cannot be penetrated by the digestive fluids of our bodies. If, therefore, we eat, say, a raw potato, it cannot be digested for the reason explained. When, however, we cook the potato the starchy contents of the cells swell until the walls burst, releasing the contents. Further, the starch becomes changed by the cooking into a soluble form, and so when we take it into our bodies we are able to make use of it. Before cooking the starch is in an insoluble form.

The most striking chemical fact about the potato is its richness in starch, and it is indeed one of the chief commercial sources of that substance. Its starch grain is specially large. When we find potatoes "waxy" after cooking we may know that they contain a considerable quantity more than usual of proteid, for the appearance called waxiness is due to the coagulated proteid holding together.

The cells of a raw potato with tough walls

Potato cells after cooking, with fragile walls

THE ANIMAL THE WORLD NEARLY LOST



One of the most astonishing romances of animal life is the story of the American bison. It roamed the plains of North America in millions, but owing to senseless slaughter it was almost exterminated. Then a few pairs were protected in reservations, and these have now multiplied till there are large herds in special National parks in both the United States and Canada. As late as 1871 a herd was seen in Arkansas 25 miles wide and 50 miles long. It was estimated to contain four million animals. While the European bison is a denizen of the forest, the American bison is a grazing animal of the plains. Here we see a cow bison with her calf. The bulls often weigh a ton

TREES THAT SHOW HOW THE PREVAILING WINDS BLOW

A growing plant always takes the line of least resistance. For example, roots in the ground when they come to a large stone change their direction and grow round it. Similarly, when a plant like a tree is young it takes very little to make it grow in a particular direction. If the prevailing winds are all in one direction the tree will grow with a tilt in that direction. We may see whole rows of trees growing like this in the Fen District of England. Here is a tree which has been made to grow horizontally by the wind at Cockersand Abbey

Of course it is when a tree is in the pliable state of youth that the winds by blowing upon it are able to bend it more or less permanently and make it grow in a horizontal direction. It will always be found that trees deformed in this way are in exposed situations. Here, for example, is an old pine tree on top of Sentinel Dome on the crest of the High Sierras in Yosemite National Park, California. It is rather remarkable that this tree is able to get nourishment by sending its roots down through cracks in the hard granite

A MARVELLOUS DISCOVERY IN THE SKY

The vast areas of Space in which circulate not merely millions of suns and worlds, but millions of universes, become more staggeringly wonderful the more we know about them. Modern scientific instruments, like the huge 200-inch telescope at Mount Palomar Observatory in America and the spectroscope, are ever revealing fresh wonders. In these pages we read something about recent discoveries. What were thought to be empty spaces in the heavens are now believed to be incredibly vast masses of dark cosmic dust and gas. In fact, all space is now believed to be filled with gas that is very thin and drawn out

THE knowledge which men of science now have of the Universe, even in its very distant regions, is truly astounding. Those early astronomers who first scanned the heavens would have been astonished could they have known a tithe of what any intelligent boy or girl can know to-day.

This knowledge has come through the brain of man, but not the brain of the astronomer only. Men of science in many realms have been at work, and by their discoveries and inventions they have helped the astronomers to pierce the blackness of distant Space and fathom its mysteries

We owe the knowledge of the heavens which we have to-day to the astronomer, the photographer, and the inventors and perfecters of the telescope and spectroscope. The telescope magnifies or brings near the distant object, the photographic plate records it permanently for examination, the spectroscope reveals what the distant body is made of, and the astronomer, with the aid of other men of science, by careful examination of this information, is able to use the knowledge as a detective uses his clues, and to piece together the story of happenings in distant Space and distant Time

The Wonder of the Spectrum

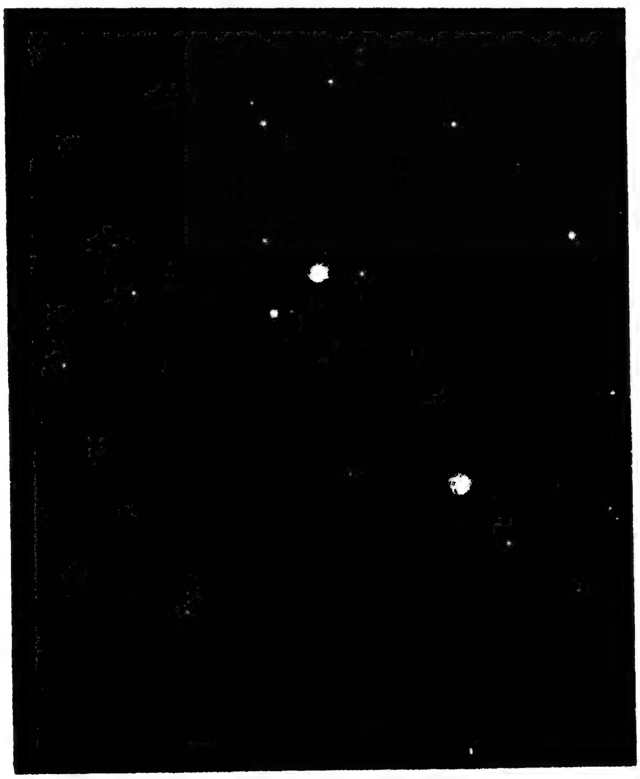
We read on page 41 something about the amazing vastness of Space, and of the thousands of millions of miles which separate one star from another. It used to be thought that this Space between the stars—Interstellar Space, as it is called—was quite empty. Then men of science, discovering that light comes to us in waves, reasoned that waves cannot pass through nothing; they therefore supposed that all Space was filled with a very thin substance, far too elusive to be collected or handled, which they called ether. No one really knows, however, whether ether actually exists.

But a few years ago a very wonderful discovery was made A scientist was examining one of the stars in Orion's Belt by means of the spectroscope, which breaks up the light.

On the spectrum, or band of colour, different lines appear according to the substance whose light is being examined The star in Orion which was being examined was what is called a binary; that is, it really consists of two stars circling round one another. When its light is examined by the spectrum the lines shift as the stars revolve round one another.

Queer Behaviour of a Line

The astronomer who was using the spectroscope noticed that one line behaved quite differently from all the rest. While they shifted to and fro, it remained still. He came to the conclusion that this line must be caused by a gas somewhere between us and the Orion star, and from the nature of the line he supposed it to be calcium gas.



The Coal Sack, a jet black patch in the sky near the Constellation of the Southern Cross, also shown in the photograph. This was once thought to be empty space, but is now believed to be an immense cloud of dark cosmic dust and gas

Other scientists got to work, and soon it was found that when the light from other stars was examined similar stationary lines appeared The matter was reasoned out, and men of science are now convinced that the vast Space between the stars themselves is filled with gas, and that it is this gas that causes the stationary lines.

We may think our atmosphere not very dense, but the gas that fills Space is so drawn out and thin that scientists reckon it would take a million cubic miles of it to weigh as much as a cubic inch of air. Yet so vast is Space that if all this very thin and drawn out gas were brought together, there would be more matter than is contained in all the thousands of millions of stars.

Before we go any farther, let us see if we can get some idea of the almost incredible smallness of the atom There are two or more atoms in every molecule of matter, and the molecule is so small that if 40 million molecules of gas were ranged in a row side by side they would scarcely extend for an inch

A Drawn Out Gas

In the gas that fills Space there is only one atom in every cubic inch, and, according to Sir Arthur Eddington, one of these atoms would, on the average, move in a straight line for about seven years before coming into collision with another atom, and during that time it would travel farther than the distance from the Sun to Jupiter; that is, 483,000,000 miles.

In other words, this gas that fills Space, or cosmic gas, as men of science call it, is so thin and drawn out that it is only one million million millionth of the density of water.

It used to be thought that distant Space was intensely cold; indeed, when far removed from the Sun the temperature of a solid or liquid body falls to as low as 270 degrees Centigrade below freezing point.

But scientists now tell us

that electrons or particles are torn from the atoms of the cosmic gas by the influence of ultra-violet light from the stars, and are set moving at terrific speed. This motion causes the gas to reach a temperature of about 10,000 degrees Centigrade. Owing, however, to the fact that the gas is so very rarefied, a solid body immersed in it would not feel the heat.

Of course this gas that fills all Space is quite different from the great masses of gas that are found in certain parts of the heavens, and are known as gaseous nebulae.

Take, for instance, the great nebula in Orion—a vast mass of glowing gas the size of which baffles the imagination. It is reckoned to be 25 light-years in diameter, or 147 million million miles. This astronomers believe to be a universe in a state of youth.

The Nebula Family

There are many other nebulae in the distant heavens of very diverse appearance, and Sir James Jeans says these are in different stages of development, and he likens them to a sequence of babies, children, boys, men and greybeards. Some, like the great nebula in Andromeda, have probably developed into a universe of stars like our Milky Way.

But these concentrated masses of gas seen at different parts of the heavens are not always bright and glowing. Some of them are dark and opaque, shutting off from our sight all that lies beyond. One such mass of dark gas is seen in Orion, where there is a definitely black mass called from its shape the Horse's Head. The great 100-inch telescope at Mount Wilson Observatory has enabled a magnificent photograph of this to be taken, and it is seen on the opposite page.

Another such mass of dark gas is seen in the constellation of the Southern Cross. It is known as the Coal Sack, a name given to it by the early navigators and astronomers, who supposed it to be a yawning cavity among the stars, a great hole or kind of tunnel in the stellar system.

All these dark spaces in the heavens were formerly supposed to be such holes or vast areas where there were no stars at all. Scientists, while believing this, realised the difficulty of the theory, although they had no alternative suggestion to put in its place. If these black patches were really empty spaces without any stars at all in them, then they must be long and tubular in shape. This could be the only explanation of their blackness, for as we looked through our telescopes at the distant confines of space we should, if the emptiness extended for only a few million miles, see some stars in the remoter distance. But here were black patches with nothing showing at all.

As Dr. Robert Trumpler, of the famous Lick Observatory in California, says: "A real vacancy of stars could only appear as such if it extended all through the depth of our stellar system. In other words, it would have to be like a narrow straight tunnel, some 10,000 to 20,000 light-years long."

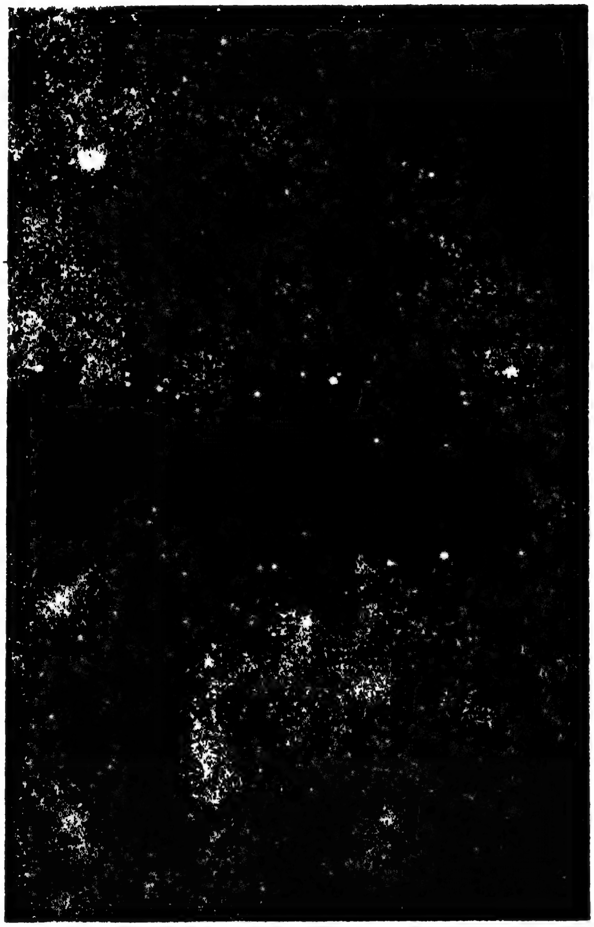
Too Remarkable a Coincidence

To be seen as an empty space, such a vast tube would have to be pointed exactly at the solar system, and that one such tube might be so pointed was quite possible. But that there should be several hundreds of these tubular spaces all pointing exactly at the solar system seemed too remarkable a coincidence to occur. The new discovery about the dark patches of cosmic dust in space has solved the difficulty. We now know that in these black parts of the heavens the real fact is not that there are no stars, but that a dark screen shuts them off from our sight.

The dark patches are really dark nebulae made up of fine cosmic dust. Speaking of these, Dr. Trumpler says: "Not all nebulae, however, cause complete obscuration; more often they only dim the light of the stars seen through them. The frequent occurrence of obscuration phenomena finally leads to the question: Is there any place where space is completely empty? Or is there a fine material substratum permeating all interstellar space? If so, a general absorption of light in space must be the consequence.

"According to our present knowledge, we may say that outside of our Milky Way, space must be of nearly perfect transparency. On the other hand, evidence has recently accumulated which indicates that light absorption within the spaces of our galactic system is not negligible. Not only do we find dark matter of wide distribution in our galaxy; its presence is even noticeable in distant stellar universes.

"The matter constituting our universe is evidently found in either of two states; in organised bodies like the stars; or in unorganised chaotic masses of tiny particles mostly dark, only in few places becoming visible as nebulae."



The Great Rift in the Constellation of Ophiuchus, or the Serpent Bearer, now believed to be not an empty space but a huge dark nebula

Ever New Worlds to Find

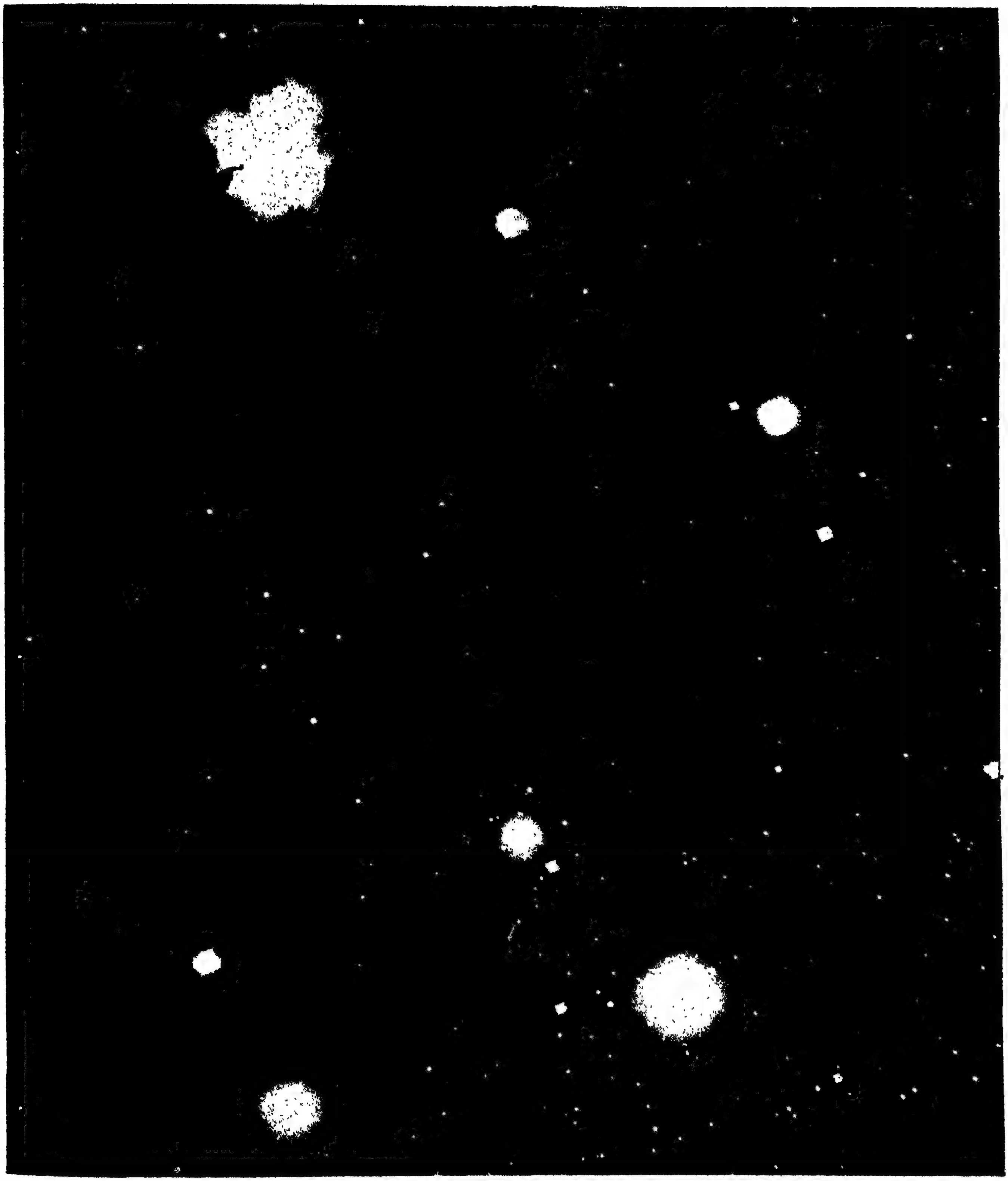
Some scientists in the latter part of the 19th century used to speak and write as though almost everything about the Universe and matter had been discovered. Like Alexander the Great, they seemed to sigh for new worlds to conquer. How very far such an idea was from being the truth has been proved by the amazing discoveries of the 20th century. Indeed, we have discovered more about the Universe in the last quarter of a century than was discovered in all the previous centuries, and the more we know the more wonderful it all is, and the more seems to be awaiting discovery.

With increasingly powerful telescopes such as could not be imagined years ago, and with the enormous improvements in photography, both of the camera and of the highly sensitive plate, it is possible that the next quarter of a century may bring to our knowledge stupendous facts about the universe that are not even dreamed of now. We may perhaps look back with enormously extended knowledge in twenty or thirty years' time and think smilingly of the little we knew in these passing days.

We are overwhelmed by the immensity of space and all it contains, and it is not surprising that more and more scientists seem to arrive at the conclusion that behind it all there is a guiding intelligence.

Increasing knowledge, so far from leading to pride and arrogance, has only made scientific men more humble, both as regards their present knowledge and what they one day hope to know.

THE DARK HORSE'S HEAD IN THE HEAVENS



Here is a very remarkable photograph of part of the heavens in the direction of the constellation of Orion. It was taken at Mount Wilson Observatory with the great 100-inch telescope, and was given three hours' exposure. The picture shows part of a nebula or mass of glowing gas in Orion, but the interesting thing about the photograph is the dark object in the middle of the picture. This is sometimes called the Dark Bay, and at other times the Horse's Head, because of a fancied resemblance to the shape of a horse's head. This dark patch, like others in different parts of the heavens, was once supposed to be a great cavity extending tunnel-like into space among the stars, but it is now known to be an immense cloud of dark matter shutting out our view of the stars beyond. Such black patches, now believed to be dark nebulae, are found only in or near the Milky Way. In some cases the dark patches merely dim the light of the stars behind them so that only the brightest are visible, just as only the brightest lamps in a street can be seen through a thick fog

HOW WE CAN FIND THE TRUE NORTH

Those interested in astronomy may carry out a fascinating experiment by which they will be able to find the true north accurately

We choose a window in the house which looks out on the north and from which we can see almost as far down as the horizon From the top of the window we hang a long plumb line, and in order that it may not sway about in the wind we allow its bob to hang in a basin or bowl of water When the plumb line has come finally to rest we stretch it taut in that position

presents, and the meridian, as we read on page 30, is an imaginary circle in the heavens exactly above a great imaginary line going round the Earth. This vertical plane will intersect the horizon in its true north point.

As we probably know, the Pole Star is not exactly at the North Pole of the heavens Every 24 hours it describes a small circle round the actual North Pole, so that in the 24 hours it crosses the meridian twice. The interval between the two crossings is nearly twelve hours The Pole Star always

Of course we must be careful that the short plumb line is hanging perfectly free and still when we have made our adjustment. If we place a lamp behind our head with the light shining on the plumb lines they will be illuminated so that we can see them clearly.

Having brought our plumb lines to the right position we can then make two permanent marks in the plane of the lines, as for example, by placing drawing pins in the floor, which will give us true north for future use If

Here is an interesting experiment which any boy or girl can carry out in the house. It is an experiment for finding true north. All we have to do is to hang two plumb lines with their bobs in bowls of water to prevent swaying, and adjust one to the other so that they will both be in a line with the Pole Star and the star Mizar in the Plough. A lamp placed behind our head will illuminate the lines and make them quite visible in the darkness

Now from a table somewhere in the room we hang another plumb line, this time a short one, and here again we allow the bob to rest in water, so as to prevent undue swaying. For ease of observation we should see to it that the cord or string of each plumb line is white

Next we have to adjust the short line so that the plane passing through the two lines shall also pass through the Pole Star when it crosses the meridian By a plane we mean a flat level surface, such as a sheet of paper

comes into this position of crossing the meridian when the star Mizar in the Plough is also on the meridian. What we have to do, therefore, is to watch closely for the time when the long plumb line hanging in the window passes through both the Pole Star and Mizar.

At that moment, lying on the floor, we place our eye near the floor and move the table with its short plumb line carefully and steadily till that line is in the plane with the long line and the two stars named.

we can continue our north line into the garden we could stretch a while string between two small posts on the line, or mark an arrow pointing true north on the path or paving.

An experiment of this kind carried out with care will give us the faculty of being accurate, and will certainly be a good exercise as well as an excellent amusement. It thus has an advantage far exceeding the mere purpose for which we carried out the experiment, namely, the finding of the true north as seen from the window of our house.

WARMING A HOUSE BY 'RAL

Many houses and most large buildings are now warmed by what is known as central heating. This is generally done by means of hot water circulating in pipes, and it is possible because of the fact that water is heated by convection, that is, as the lower layers become warmer they rise and the colder water from above flows in to be warmed in its turn. Here we see how this natural principle is used in central heating

In warming a house by central heating, the boiler is placed on the ground floor or in the basement to take advantage of the fact that water is heated by convection.

When the lower part of the water in an enclosed vessel or series of pipes is heated it becomes less dense and will rise, the colder water above descending to take its place. Thus, a regular circulation is carried on till all parts of the fluid are at the same temperature.

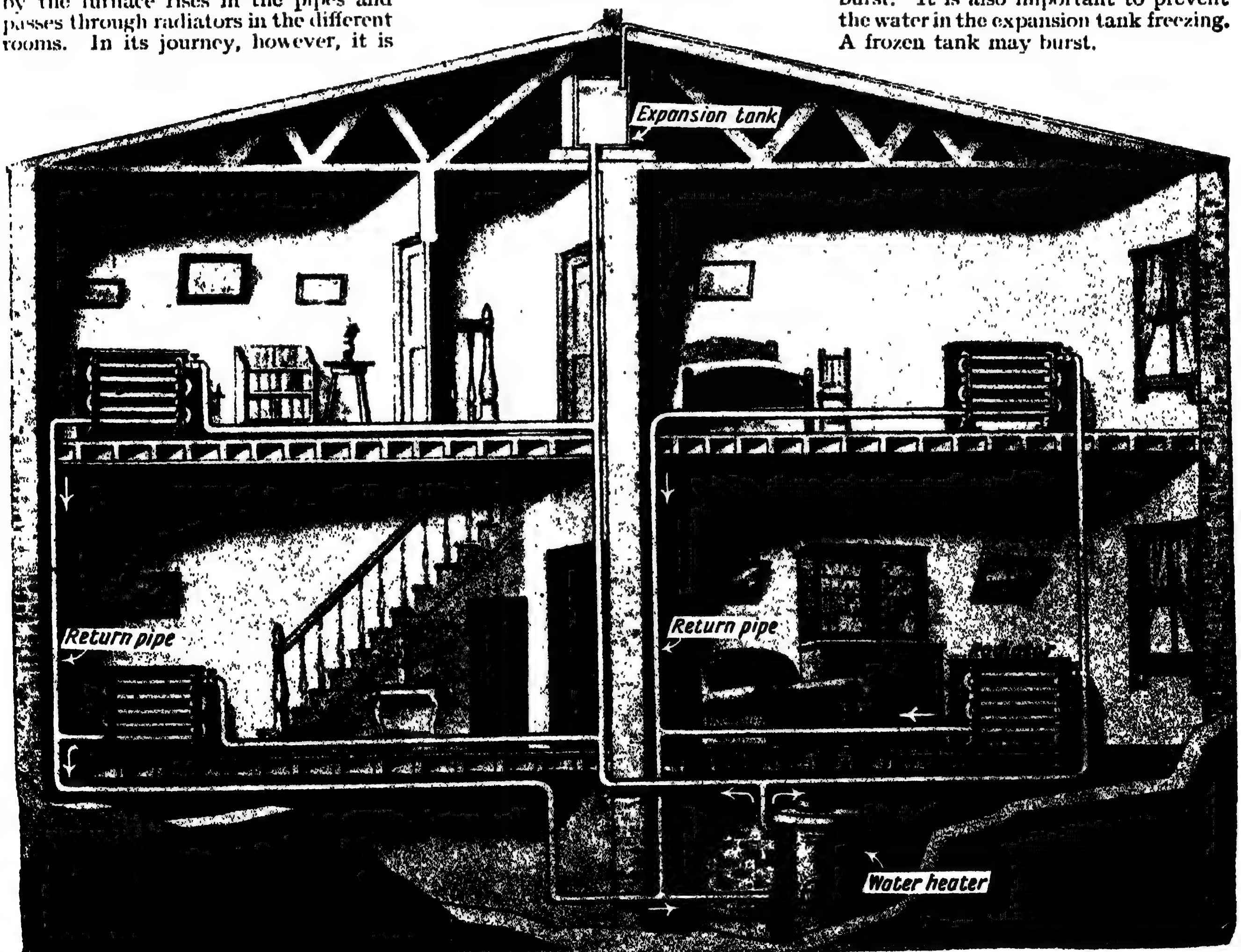
The picture makes clear how the system works. The water as it is heated by the furnace rises in the pipes and passes through radiators in the different rooms. In its journey, however, it is getting cooler, and so having warmed the room it descends through a return pipe to the boiler once more to take the place of the hotter water that is rising.

The rooms become heated by radiation from the metal ra liators, and as these are on the floc warm air is constantly rising to th upper part of the room, while the cc ler air descends to be warmed in its turn by the radiators

Radiators are generally placed near windows so that when these are opened for ventilation the air can pass over the radiators before going into the room.

As radiators dry the air as well as warm it, it is usual to keep a dish of water on a radiator so that the air may have the necessary moisture. Another way is to keep a growing plant like a fern or aspidistra in the room. The leaves then give off moisture.

But there is one important point that must not be overlooked. Water expands when it is heated, and so at the top of the house it is necessary to have an expansion tank which allows for the expansion of the water when it is hot. If it were not for this the pipes might burst. It is also important to prevent the water in the expansion tank freezing. A frozen tank may burst.

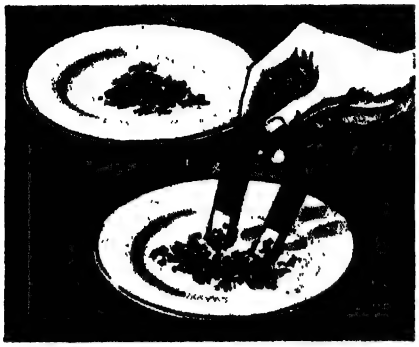


This picture shows how a house is heated by hot water pipes supplied from a boiler in the basement. The water, as it becomes warm, flows from the top of the boiler and rises through pipes to radiators in the rooms. When it has cooled it returns to the heater to be warmed once more, the whole process being repeated again. The operation is the same when the boiler is in a ground-floor room

EXPERIMENTS WITH SIMPLE CHEMICALS

We can all perform chemical experiments without going to a laboratory and having expensive apparatus. Nor do we need to get together a collection of elaborate chemicals such as are found in a school or college. There are plenty of chemicals in the home, and with very little apparatus indeed we can carry out some interesting experiments.

For example, take a rusty nail or other iron object that has been lying

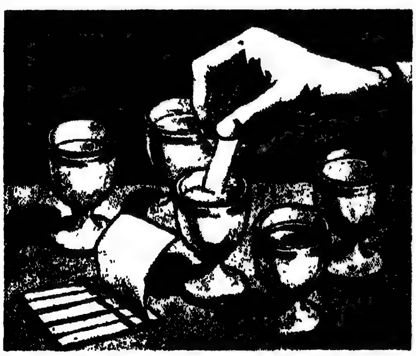


Separating iron filings from red rust

outside and scrape the red rust into a plate with an old knife. Then take some iron filings, such as we can ourselves file from a nail or screw. Mix the two substances together, and then try to separate them.

How will you do this? Well, there is a very simple way. Hold a magnet over the mixture, and at once the iron filings will adhere to the ends of the magnet, but the red rust will be left behind in the plate.

The magnet attracts the iron filings, but it does not attract the rust, for the simple reason that the rust, which is iron oxide, is a different substance with different qualities, although it contains iron. The oxygen of the air, which is a chemical element, combined with the iron of the nail, which is also



Testing acids and alkalies with litmus

an element, to form oxide of iron which is a chemical compound and has qualities different from the elements.

Another interesting experiment can be carried out with red and blue litmus paper, of which we can obtain a few strips for a penny or twopence at the chemist's. We place in a number of egg-cups or saucers various liquids, such, for example, as soda water, lemonade, liquid ammonia, salt water, and vinegar. We want to discover which of these are acids and which are alkalies and which are neutral salts.

Ammonia from soda and sal-ammoniac

We do this by testing them with the strips of litmus paper. The acids will turn blue litmus red, the alkalies will turn red litmus blue, and the neutral liquids will have no effect on either.

Here is another interesting experiment. We take a little sal-ammoniac and crush it into small fragments. Then we place it in an egg-cup or saucer with some crushed or powdered washing soda. When we mix the two together we shall find that if we put our noses near the mixture that ammonia gas is being given off. The elements of which the two substances are combined re-arrange themselves

Hydrogen from iron filings and acetic acid

into new combinations and ammonia gas is formed, while common salt and water are left behind.

We can make hydrogen gas in a test tube by putting inside a few iron filings, and then pouring over them a little acetic acid. Vinegar is really acetic acid, but the acetic acid we get at the chemist's is stronger. We can light the hydrogen with a match at the mouth of the tube as it is escaping.

Here is an experiment which we can carry out with a little soap, soda and water. We dissolve some ordinary yellow soap, say, half an ounce, in two cupfuls of distilled water—freshly collected rain water will do. The soap needs to be flaked, stirred up in the

Making hard water with salt

water, and the whole heated gently without bringing it to the boil.

When we have the solution, we drop in a couple of tablespoonfuls of ordinary cooking salt well ground up by means of a rolling pin. This salt will dissolve in the water and at once flakes will be seen floating. The explanation is that the water, owing to the salt dissolved in it, has become hard, and hard water will never hold soap in solution properly.

To prove that some substances will not burn, that is will not combine with oxygen, we can carry out this experiment. Soak a piece of white cotton in brine several times, so that there may be a good coating of salt. Now with the cotton tie up a light ring and suspend it from a metal rod. At

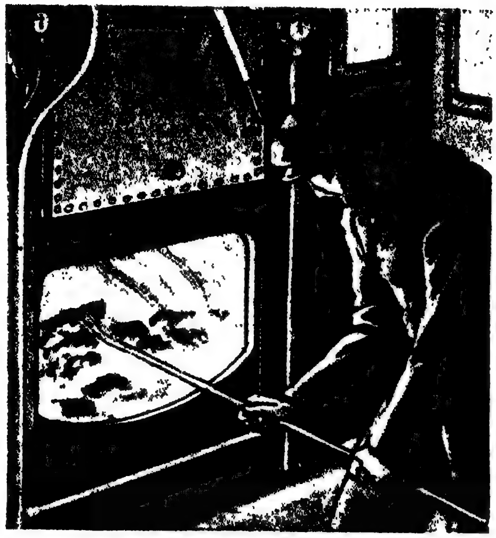
The cord that will not burn

the same time suspend another ring with unsoaked cotton.

Set light to both the threads and we shall find that while the ring suspended from the untreated cotton falls, the other one remains suspended because the coating of salt does not burn.

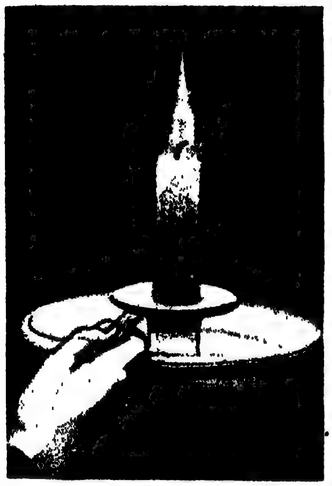
DIFFERENT WAYS IN WHICH THINGS BURN

An explosion of gunpowder



A furnace burning fiercely

The fire in the grate

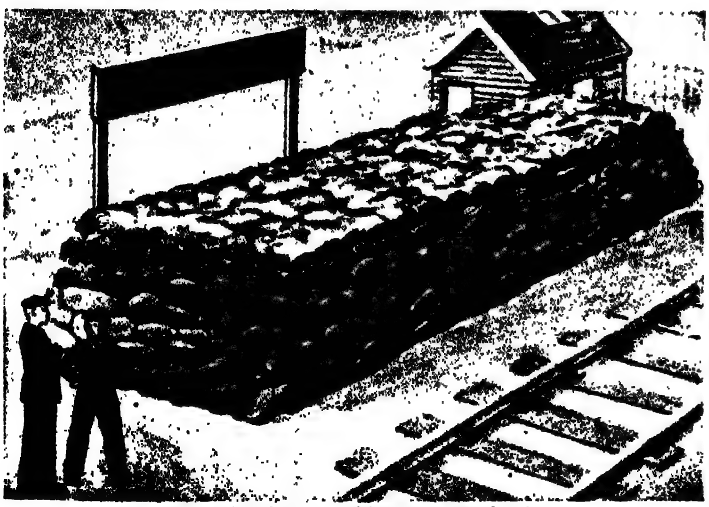


A burning candle

The slow-combustion stove

A smouldering stack

Iron rusting

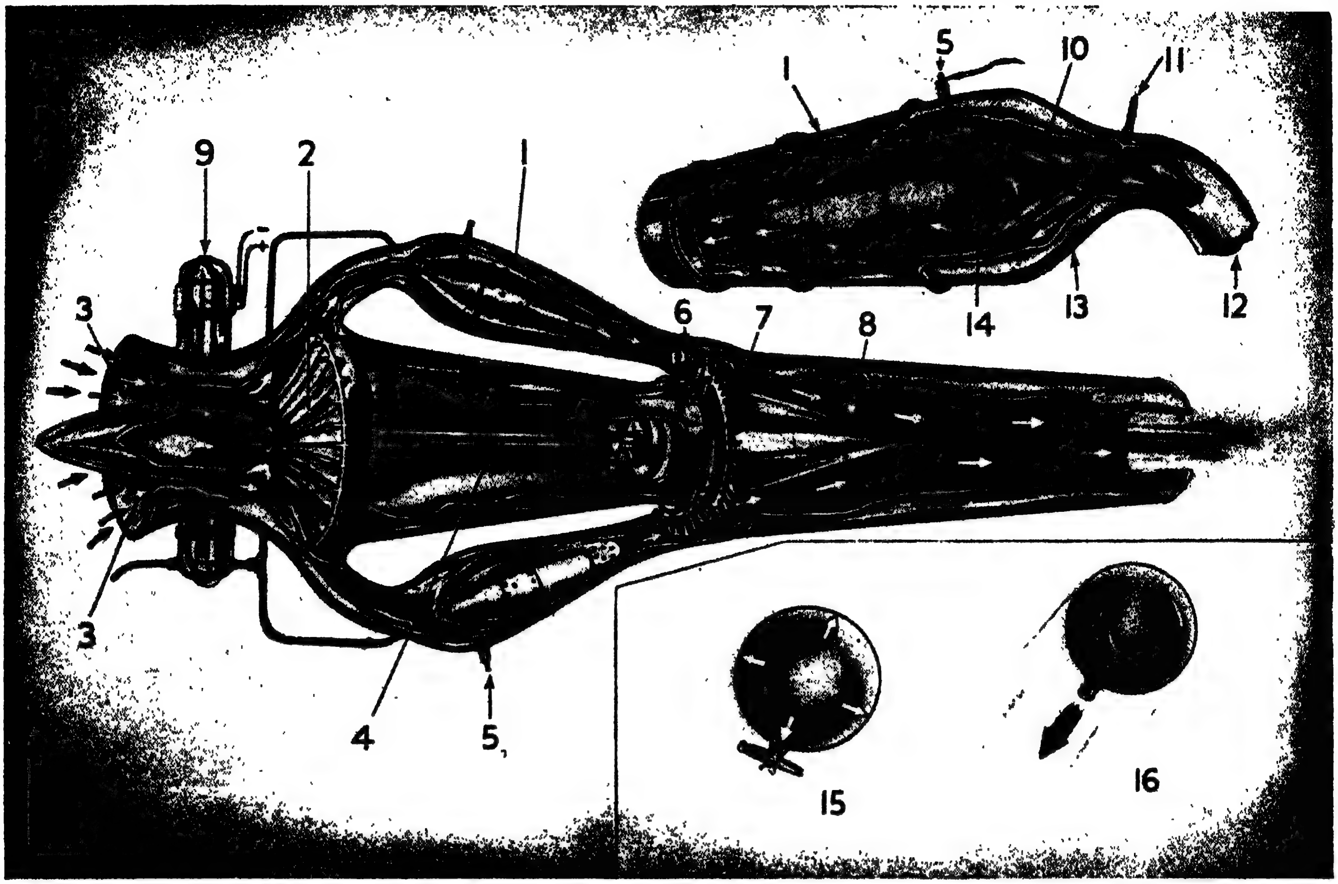


A stack of coal oxidising very slowly

Athletes in whose body carbon is burning

Burning or combustion is really the combination of a substance with the gas oxygen, which forms part of the atmosphere. It is not always accompanied by flame, and the burning may be fast or slow. When gunpowder explodes, the burning is very rapid. It is slower in the locomotive furnace and still less rapid in the fire of our grates. When a candle is alight it is burning, but with less heat than the fire. In an anthracite stove the burning goes on slowly, and still more slowly when a haystack gets hot and burns spontaneously because it was stacked when damp. The rusting of iron is really slow burning, and a pile of coal in the open air or cellar is continually burning at a very slow rate, for the oxygen of the air is combining with it. When we breathe burning is going on, for the carbon of our body is combining with the oxygen of the air, and the faster we move and breathe the faster the burning goes on

HOW A JET ENGINE WORKS



This drawing shows you the inside of a complete jet engine and the chief parts that make it work : 1, the combustion chamber ; 2, the compressor wheel ; 3, the air intake ; 4, the shaft connecting compressor and turbine ; 5, the igniter or sparking plug ; 6, the fixed blades of the turbine ; 7, the moving blades of the turbine ; 8, the cone against which the gas jet thrusts and drives the aircraft forward ; and 9, the starter motor. The smaller drawing in the top right-hand corner, shows the inside of the compression chamber ; 10, the space between the inner and outer chambers ; 11, fuel feed pipe ; 12, port by which compressed air enters the chambers ; 13, casing of outer chamber ; and 14, nozzle spraying paraffin vapour into the compressed air. The smaller drawing in the bottom right-hand corner shows how air released from a toy balloon pushes it forward

LOOKING at the drawing at the top of this page showing the inside of a jet engine you would think that jet propulsion was a very complicated thing indeed. Yet nothing could be more simple than its principle.

The jet engine has few moving parts, and it develops such high power that aircraft fitted with it can fly faster than sound.

Jet propulsion is based on the fact that when a quantity of air or other gas is compressed into a very small space it struggles to escape. If the only way it can escape is through a small opening, the escaping gas will come out with such force that the container in which it was compressed will be forced forward in the opposite direction.

Blow up a toy balloon and it immediately begins to swell, and the more air you blow into it, the bigger becomes the balloon. In other words, a lot of air is being compressed into a small space. When the balloon has been well blown up, close the opening with a clothes-peg. Pull the peg away quickly and the air rushes out with such force that the balloon is pushed forward.

What happens in the deflating balloon is exactly what happens in a jet engine; only on a very much larger scale and with the assistance of mechanical devices to increase the pressure of the gas mixture so that it is forced from the rear of the engine with tremendous force.

In the jet engine pictured above, a small electric motor (9) starts to revolve the compressor wheel (2). The blades on the compressor wheel turn in an anti-clockwise direction and suck in air through the intake (3). The air is sucked in so quickly and in such large quantities that it is compressed and forced into the combustion chamber (1 in the large drawing).

The smaller drawing on the top right shows the interior and principal parts of the compression chamber. The compression chamber has an inner and an outer chamber; some of the air forced from the compressor passes through the outer chamber (10) and some through the inner chamber. The air in the inner chamber mixes with paraffin vapour forced through a jet (14) supplied by a pipe (11) led from the fuel tank. On top of the compression chamber and leading into it is an electrical sparking plug, the spark from which occurs inside the compression chamber and causes the mixture of air and paraffin vapour to burn. This makes the mixture very hot so that it expands rapidly and forces its way out through a nozzle at the end of the compression chamber and strikes the moving (6) and fixed (7) blades of a turbine. This causes the turbine to revolve. Attached to the plate holding the blades is a shaft (4), the other end of which is attached to the compressor and turns it round. This means that once the engine has been started, the starter motor (9) can be switched off, and as long as air is sucked in, mixed with paraffin and ignited, the engine is self-acting.

After the air and paraffin mixture passes through the turbine blades it is forced into the rear nozzle of the engine, where there is a cone (7) against which the jet of high pressure and expanding gas reacts, causing the engine and the aircraft to which it is fitted to move forward. This is the same principle that made the blown-up balloon jump forward when the air escaped.

A BATTLE WON BY CAMP-FOLLOWERS

Every Scotsman loves to think of Robert Bruce and his great victory at Bannockburn, for it was that battle in which the Scots defeated the English that won freedom for Scotland, and the story of how a spider spinning its web taught the great Scottish hero the lesson of perseverance is a classic. Here we read the romantic story of Robert Bruce and his great victory

If William Wallace stands out as Scotland's greatest national hero Robert Bruce is a very close second, and he has this advantage that he really freed his country, which Wallace had failed to do.

The grandfather of Bruce, another Robert, had been candidate for the throne after the death of Alexander the Third, but his claim had been rejected by Edward the First when that monarch was called in to arbitrate.

With Wallace dead, and all opposition crushed for the time being, the English in Scotland became more arrogant than ever, and it was not long before the people made up their minds that they must fight for freedom They therefore looked round for a leader, and certainly no one was more worthy than Bruce.

But he was not the only noble who laid claim to the throne of Scotland. There was Sir John Comyn, who was called the Red Comyn to distinguish him from his kinsman, the Black Comyn, so called from his swarthy countenance

Scotsmen Fight for England

After the battle of Falkirk, both Bruce and Comyn had submitted to the English king and acknowledged his title as King of Scotland. They even fought with the English against their countrymen, but Bruce very soon realised how base and unpatriotic this was. In one of the skirmishes between the English and a band of patriotic Scots, Bruce was present and helped the English to gain the victory.

The fight over, he sat down to a meal with his English friends and allies without washing his hands, on which there still remained some of the blood shed during the battle. The English lords noticing this said to one another in mockery, "Look at that Scotsman who is eating his own blood." The words were like a dagger stab to Bruce.

He realised that the blood upon his hands might, in a very real sense, be called his own, because it was that of his brave fellow-countrymen who were fighting for the freedom of their native land. He, on the other hand, was assisting the oppressors of Scotland, and the only thanks he got was their laughter and ridicule. So shocked was he at this revelation of his own baseness that he at once left the table and going into a neighbouring chapel prayed to God to forgive the great crime of which he had been guilty.

Then, before the altar, he made a solemn vow that he would do all in his power to atone for the sin and deliver Scotland from the foreign yoke. From that time onwards Bruce never fought for the English again.

Bruce was not only a strong and

Robert Bruce receives a lesson in perseverance from a spider

brave man, but a very able man, too, and he realised that there was no hope for Scotland unless the nobles and the people were all united against the common enemy. It was useless to think of defeating the English as long as there were rival Scotsmen for the Scottish throne, so Bruce went to the Red Comyn and said, "We must come to an agreement. If you will help me to get the Scottish crown I will give you my lands. On the other hand, if you prefer it I will help you to win the crown if you will agree to give me your lands."

It is said that Comyn decided to take Robert Bruce's lands, and that in return he agreed to help him mount the throne, but Comyn was a traitor and instead of keeping his word he went and told King Edward of the bargain that had been made. Some time later Bruce and Comyn met by arrangement in a church at Dumfries. What passed between them is not known, but before long they quarrelled.

Some records say that Bruce charged the Red Comyn with having betrayed to the English his purpose of rising against King Edward, but whatever the cause of dispute the two nobles came to high words and Bruce in a passion drew his dagger and struck a blow at Comyn. Then he rushed out of the church and called for his horse, saying to two gentlemen in attendance upon him, "I doubt that I have slain the Red Comyn."

The Power of the Church

"Do you leave such a matter in doubt?" said one of the gentlemen. "I will make sure," and thereupon he and his companion rushed into the church and killed the Red Comyn with their daggers.

There was now no doubt that King Edward of England would seek to execute vengeance upon Bruce, who had made things still more difficult for himself by committing sacrilege in a church. In those days the power of the Church was a very real thing, and not long afterwards Bruce was excommunicated by the Pope on account of the killing of the Red Comyn on consecrated ground.

Bruce became desperate. He determined on a bold bid for fortune, and drawing a band of followers together asserted his claims to the throne and was crowned king at the Abbey of Scone. The ancient crown of Scotland had been carried away to England by King Edward, but a small circlet of gold was hurriedly made for the occasion, and as the Earl of Fife, whose duty it was to crown the king, would

not attend, the ceremony was performed by his brave sister the Countess of Buchan.

Edward was infuriated, and, although he was now old and feeble, he declared at a great festival of his Court that he would take ample vengeance on Robert Bruce. Gathering a powerful army, he started for Scotland. But, meanwhile, Bruce was defeated in a battle by the English Earl of Pembroke, and his horse was killed under him in the action. He was taken prisoner by a Scottish knight who was serving in the English army. This man, however, felt that he could not put his brave fellow-countryman into the hands of the English, and so he allowed him to escape.

This was very fortunate for Bruce, for had the Scottish knight not behaved in this way he might scarcely have been heard of to-day Bruce with a few brave followers, including the young Lord of Douglas, whose name afterwards became a household word as the Black Douglas, fled to the Highlands and there hid from the English. They had to hunt and fish in order to obtain food, but they were not short, for Douglas was very dexterous in fishing and in hunting and killing deer.

Severe Punishment

Again Bruce gathered a small army, but again he was defeated, and he had many breathless escapes from capture. His young brother, Nigel Bruce, was cruelly killed, and his queen and the countess who had crowned him were placed in strict confinement and treated with great severity. The Countess of Buchan was imprisoned in the Castle of Berwick, being placed in a cage made on purpose for her. Some Scottish writers say that this cage was hung over the walls with the countess in it, just as a parrot's cage is placed outside a window, but this is not true. The cage, made of wood and iron, was placed in a compartment in the castle.

Things now seemed desperate for poor Robert Bruce. He went across to an island off the coast of Ireland with a few men, and so unlikely did it seem that he would ever again be able to make headway against the English, that he decided to go off to the Holy Land and spend the rest of his life fighting against the Saracens. Yet to do so seemed to him like desertion of his country, and he knew not what decision to come to.

Lying in his rough cabin and greatly perplexed by his thoughts, he happened to look up towards the roof and noticed a spider hanging by the end of a long thread which it had spun. It was endeavouring to swing itself from one beam in the roof to another, so as to fix a line on which to weave its web. Again and again the spider tried to reach the beam, but without success. Bruce counted no fewer than six such attempts, and realised that he had fought six unsuccessful battles against the English and their allies.

The Seventh Attempt

"Well," thought he, "this poor spider is in just the same situation that I am. It has made many attempts, and failed every time. If it makes another attempt to fix its thread and is successful, I will venture a seventh time to try my fortune in Scotland, but if the spider shall fail I will go off to Palestine to fight the infidel, and never again return to my native country."

The king watched the spider. Gathering all its force, the creature made a great swing on the thread and this time succeeded in reaching the opposite beam. It was like an inspiration to the dejected king. He suddenly became full of hope for the future, and there and then determined to renew his efforts to free his native land and rule as a real king.

Gathering a few followers, he went across to the Isle of Arran in the mouth of the Clyde, and, landing, asked the first woman he met what armed men there were on the island. She replied that there was a body of armed strangers who had defeated the English governor of a castle and killed him and most of his men. They were now hunting in the Isle of Arran.

The king asked to be guided to the woods where they were, and at frequent intervals he blew his horn. Now the armed Scotsmen were Black Douglas and some of his followers. The moment Douglas heard the horn he knew at once that it was Robert Bruce, and soon the king and his followers met, with great joy. They began to make plans for gathering an army and beating the English. It was arranged that Douglas should go first to the mainland in disguise and raise his own followers, while another friend of Bruce, named Cuthbert, was to go across to the mainland of Carrick, and if he found the people disposed to take up arms against the English he was to light a fire on a headland on the Ayrshire coast opposite the Isle of Arran.

For some days Bruce watched eagerly for the fire, but there was no sign. At length through the darkness one night the flare was seen, and the king and his men went eagerly into their boats, assuming that the men of Carrick were in arms and ready to fight. When they landed on the beach at midnight they found Cuthbert alone waiting for them, but his news was bad news. Lord Percy was in the country with several hundred Englishmen and had so terrified the people that they dared not think of rebelling against King Edward.

Many Narrow Escapes

"Traitor!" said Bruce. "Why, then, did you make the signal?"

"Alas!" replied Cuthbert, "the fire was not made by me, but by someone else, for what purpose I know not, but as soon as I saw it burning I knew that you would come over, thinking it was your signal, and therefore I came down here to tell you how matters stood."

Bruce now had many narrow escapes. There were traitors among the Scots, who tried to capture him for the reward that the English king offered.

The men of Galloway, who were friends of the Red Comyn, hearing that Bruce was in their country with only sixty men, got together a band of 200 and, with several bloodhounds, pursued him.

Bruce quartered his little troop by the side of a deep and swift-running river that had steep, rocky banks There was only one part by which the river could be crossed, and that was deep and narrow, so that the men had to pass in single file, while the ground on which they were to land on the side where Bruce lay was steep and difficult. Bruce told his men to go half a mile distant and take some much-needed rest, while he watched the ford. Presently he heard the baying of the

Bruce and his brother, pressed by bloodhounds, wade down a stream to throw them off the scent

hounds, and then the approach of men. He dared not go back to rouse his followers, for the men of Galloway might pass the ford in safety, so sending a follower to awaken the men he remained alone on the bank of the river.

Presently the enemy approached, and seeing only a single man they crossed by the ford, but as fast as they tried to mount the bank Bruce killed them with his spear, and at last when his followers came up, the men of Galloway retreated and gave up their enterprise.

On another occasion, when a relative of the Red Comyn and his force were chasing Bruce, the King divided his men into three bands and commanded them to retreat by different ways, thinking that the foe would not know which party to pursue. But the enemy had a bloodhound that had once belonged to Robert Bruce himself, and when they came to the parting of the ways the dog followed the route that Bruce had taken.

The King, realising that he was again pursued, told his followers to go in different directions, but again the bloodhound followed Bruce, who was with a single follower, his foster brother. At length they came to a wood through which ran a small river. Bruce said to his foster brother, "Let us wade down this stream for a great way, so that the hound may lose the scent." They did so, and thus escaped for the time being.

Treachery Round the Camp Fire

Later on, the King and his foster brother came upon three men who looked like thieves, in the midst of a forest. These men were armed and one of them bore a sheep on his back which he seemed to have stolen. The men saluted the King and when he asked where they were going they said they were seeking for Robert Bruce, in order to join him. But Bruce suspected the ruffians, and was on his guard.

The sheep was cooked and after a meal had been eaten Robert and his brother, who were very tired, fell asleep. Thereupon the three villains rose and, drawing their swords, started up to kill the King and his brother, but the slight noise they made awakened Robert, who at once drew his sword and went to meet them. As he passed he pushed his foster brother with his foot, but the ruffians managed to kill him.

The King was now alone against three, but his amazing strength and his good armour saved him, and he killed all three of the ruffians one after another. Soon afterwards he came to a farmhouse, and there he found loyal friends.

And now something happened which was of great value to Bruce. The great English King, Edward the First, who had advanced northward as far as Burgh-on-the-Sands, died. He had been called the Hammer of the Scots, and he ordered that his bones should be wrapped up in a bull's hide and carried at the head of the English army, for he thought that his very bones would terrify the Scots. His son, Edward the Second, however, did not execute this strange command, but buried his father in Westminster Abbey, where his tomb still bears the inscription in Latin "Here lies the hammer of the Scottish nation."

Bruce's work now became easier, for Edward the Second was no warrior, and the Scots began to defeat the English and recapture their castles. At last only Stirling Castle remained in English hands, and that was besieged by Bruce's brother Edward. He made a bargain with the English commander, Sir Philip Mowbray, that the Scots should have the castle if within a year King Edward did not send an army and relieve it.

Bruce swung his pony aside and felled the English knight

Word was sent to England, and Edward the Second marched into Scotland with a large army, nearly half of whom were horsemen. Bruce could not raise anything like so large a force, but what he lacked in men he made up in ability and generalship. The place where he arranged to fight was on the banks of a little stream called the Bannock Burn, some three miles south of Stirling Castle. Between the two armies there was some firm ground and some boggy land.

Thrilling Single Combat

The English horsemen would not be able to ride across the bogs, and Bruce determined that they should not easily cross the firm ground. He therefore secretly had pits dug all over this and then covered them with turf so that they might not be seen from the English camp. Then he scattered about the ground steel spikes known as caltrops, so that the horses might be hindered as they came forward.

When the English came up it was evening, and the battle was put off till the next day. The two armies, therefore, lay in sight of each other, waiting for the morrow. Bruce went forward a little on a small pony, carrying only a battle-axe in his hand. He wanted to get a closer view of the English force.

An English knight named Sir Henry de Bohun recognised him by the golden coronet he wore on his helmet, and he thought that he would end the battle at one stroke by killing the Scottish king. He therefore rushed forward on his charger with his spear ready couched, but as he drew near, Bruce, with his powerful arm, swung his pony aside and as de Bohun galloped by Bruce rose in his stirrups and with one blow of the battle-axe felled the English knight to the ground, killing him on the spot.

The next morning the battle began by the English knights riding against the Scottish spearmen, but Bruce sent his mounted men against the English archers and soon they were all slain or put to flight. For hours the fight went on, but the English on the unfavourable ground could not use their superior forces to advantage. Their horses slipped in the pits, were maimed on the spikes, and many were slain.

Still the result was in doubt, when suddenly over the distant hill a new army seemed to be coming to the help of the Scots, with banners flying and spears glistening in the light. This was enough to discourage the English, who thereupon began to give way. The Scottish spearmen, seeing this, fought all the harder and soon the enemy was in flight in all directions. The English king himself had a narrow escape, and the victory was the most decisive the Scots have ever won over the English.

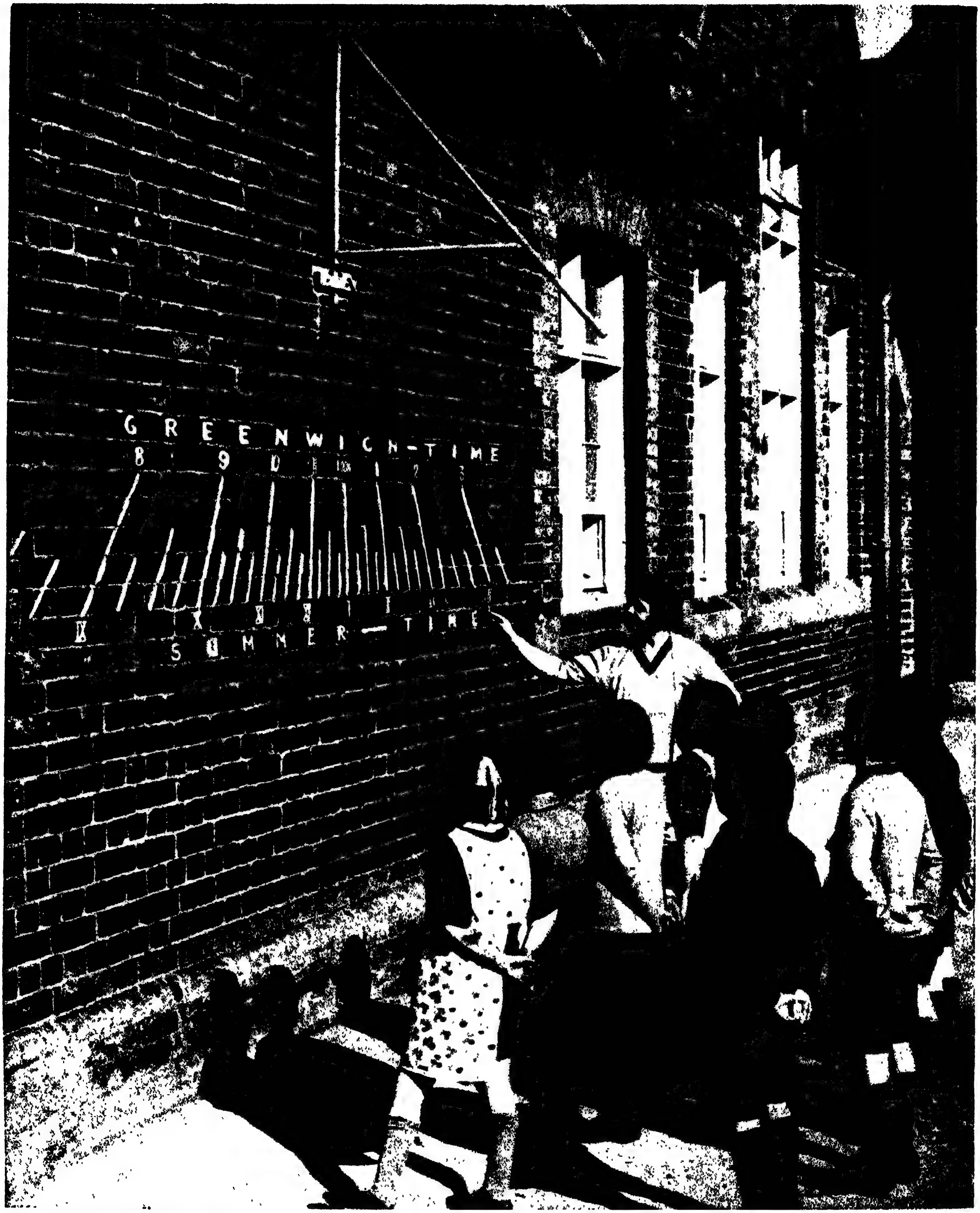
An Imitation Army

That new army coming to the aid of Bruce was merely a gathering of servants and camp-followers. So that they should not hamper the Scottish troops during the battle, Bruce had sent them behind the hill, but after hours of waiting they were anxious to see how the battle was going, and so, picking up any weapons and flags they could find, they came over the hill.

The sight of this disorderly rabble deceived the English, who were thus driven out of Scotland and left that country free of invasion for many years.

It has been said that the battle of Bannockburn was the beginning of the end of feudal warfare, for in it the knights in armour, whose personal prowess had often gained the victory, gave place to the common soldiers, disciplined, marshalled, and led by skilful generals. In other words this famous battle was won, not by the knights but by the Tommies of the Scottish army, and so decisive was their victory that, though later on their country was invaded more than once, it was never again conquered. Bruce by his patience, perseverance and prowess freed his country and won his throne.

THE SUNDIAL ON THE SCHOOL WALL



The sundial was the first instrument made for telling the time. Sundials may be horizontal or they may be placed vertically on a wall. In this picture we see a simple sundial that has been constructed on the wall of a village school at Partington, Yorkshire, and the teacher is showing a class how the sun casts the shadow of the projecting rod on the scale, indicating that it is ten minutes to two, Greenwich Time, or ten minutes to three, Summer Time. The scale has been continued down the wall so that the shadow may show both times

WONDERS of LAND & WATER

THE WAY IN WHICH WE RECKON TIME

Time is fixed by observing the Sun, or, more accurately, the stars. But for ordinary purposes of everyday life we measure the passing of Time by our clocks and watches. The reckoning of Time is a fascinating subject, and here we learn how it is done

All clocks and watches, if they are to be good timekeepers, must be set and kept right by the natural timekeeper, the Sun. It would take us too long, and we have not the delicate instruments necessary to do this for ourselves, and so we keep our clocks and watches right by making them agree with Big Ben, or the Time Signal. For the accuracy of these signals we have to thank the astronomers at Greenwich Observatory.

As the Earth turns round on its axis fresh parts of it are continually coming into the Sun's light, and so Time is different at different places. We know, for instance, that when it is midday at Greenwich it is five hours earlier in New York, and more than five hours later in Madras.

But this difference of Time applies not only to places far apart, but even to those which are only a few miles apart. Thus Birmingham time is slow of London time, Bristol slow of Birmingham, and Plymouth slow of Bristol and Dublin slow of Plymouth. On the other hand, Chatham time is fast of London, and Dover fast of Chatham.

Difficulties with Time

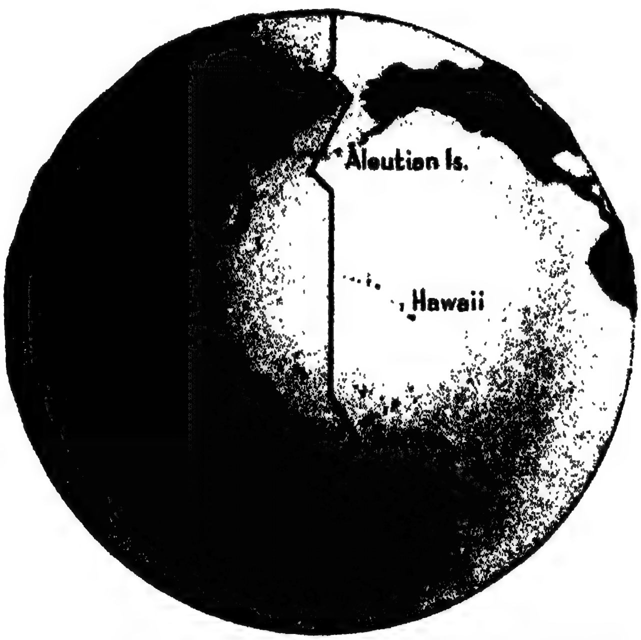
Now it would be extremely inconvenient if whenever we took a railway journey, say, from London to Plymouth, we had to keep altering our watches at every place we came to. It would also be impossible for the railway companies to make out time tables that were of any use.

To get over this difficulty civilised man has invented a system of what are known as Time Zones; that is, most countries arrange that all places within that particular country shall use the same Time. For instance, throughout Great Britain we all set our clocks by Greenwich Time, and when we say it is one o'clock at Greenwich we know that it is also reckoned as one o'clock at Dover and at Bristol and at Plymouth.

A great country like the United States or Canada is unable to do this, because the country is so wide and there are so many hours' difference between sunrise at, say, New York and sunrise at San Francisco that it would be ridiculous to have the same time for the whole country. In such a case the difficulty is got over by dividing a large country into so many zones, and each particular zone has its own Time. Also, for the sake of convenience, the rest of the world is divided into Time Zones, so that often several countries have the same Time.

For instance, some of the countries in Western Europe and a large part of Africa have Greenwich Time. There is another great zone farther east, which includes the Scandinavian countries, Germany, Italy and a large part of Africa, which has another Time, all the places in that zone keeping the same time; and so it goes on.

The map on the next page shows the various Time Zones and also the Date Line, where every day and year begins.



The International Date Line on the other side of the world where every day and every year begins

This Date Line is explained later on. The Time observed in all these zones is called Standard Time, and it is based on Greenwich, varying from Greenwich Time only by hours and half-hours, and not by odd fractions.

But what do ships at sea do? Well, matters are made simple for them. In addition to the irregular zones for land areas already mentioned, the whole Earth is divided up into 24 equal zones of 15 degrees each, and these correspond with the 24 hours of the day. All ships at sea observe the Time of these 24 Time Zones. It is only on land that the zones have to be varied and made irregular so as to link up certain areas which must for obvious reasons observe the same Time.

But there is something more we must learn about time. We all know that as soon as Big Ben begins to chime midnight the day has ended and we at once enter the new day. Similarly when midnight chimes on the night of December 31st the next moment a new year begins for us. But the New Year does not begin at the same moment for everybody, because day and night are caused by the rapid rotation of the Earth on its axis. As it turns round from west to east different places keep coming in turn into the sun's light.

On one occasion the British Broadcasting Corporation did an interesting thing at the beginning of the New Year. Various broadcasting stations in different parts of the world were linked up and we could hear the clocks strike twelve in these different cities, one after another at intervals.

Following the New Year

In some cases we heard twelve strike when our clocks had only just turned eleven, and in other cases after our clocks had struck the midnight and we had entered upon the New Year, we heard the clocks ushering in the New Year elsewhere, long after ours had begun.

But while it is perfectly true that the day and the year begin in different parts of the world at different times, it is obvious that each day and each year must be reckoned as beginning at some particular part of the Earth's surface.

Of course, as day follows day we might say a new day first dawns at any particular place. The whole world, for instance, might arrange to say that January 1st starts at the Meridian of Greenwich, that is, the line running from the North Pole to the South Pole through Greenwich. Or it might be said that January 1st and every other day first begins on the Meridian of New York or San Francisco or Pekin or Calcutta.

On the other hand, the nations might be a little jealous of one another, and each say that the day first began in its own country. But that would lead to terrible confusion.

In these days, when all the nations are so linked together and when the whole world depends for its very existence upon international trade, it would lead to chaos, if we could not agree as to the part of the Earth in which the day and the year begin.

The nations have come to an agreement on this point, and for the sake of convenience it has been decided that the New Year and every new day shall be reckoned as beginning on the other side of the world, on a zigzag line that runs down the Earth from the North Pole to the South Pole. This is called the International Date Line.

Originally the 180th meridian of longitude was selected as being most convenient, because in its imaginary passage from north to south it touched less land than any other meridian in the world, and so the great inconvenience was avoided of having numbers of people living close together being some in one day or year and others in another day or year.

This inconvenience, however, is not altogether avoided by selecting the 180th meridian, for it cuts through the Aleutian Islands and Fiji. Obviously, it would be a nuisance to have the people who dwell in these places living some in one day and some in another, so to get over the difficulty the Date Line is varied a little and made zigzag.

It first of all takes a turn, for instance, to the west to include Wrangel Island with Alaska. Then it turns east so as to include the East Cape Peninsula with Siberia. Next it turns west again, so that the whole of the Aleutian Islands may be on the same side of the line and have the same date as one another and as the United States, to which they belong.

After this it turns back again to the east and follows the 180th meridian south for many miles, as there is practically no land of any importance that need be considered. But south of the Equator the Date Line again takes a turn eastward to include all the Fiji and Tonga Islands on the west side, and thus give them the same date as one another and as New Zealand, with which they are linked. It then returns to the west and continues along the 180th meridian to the South Pole.

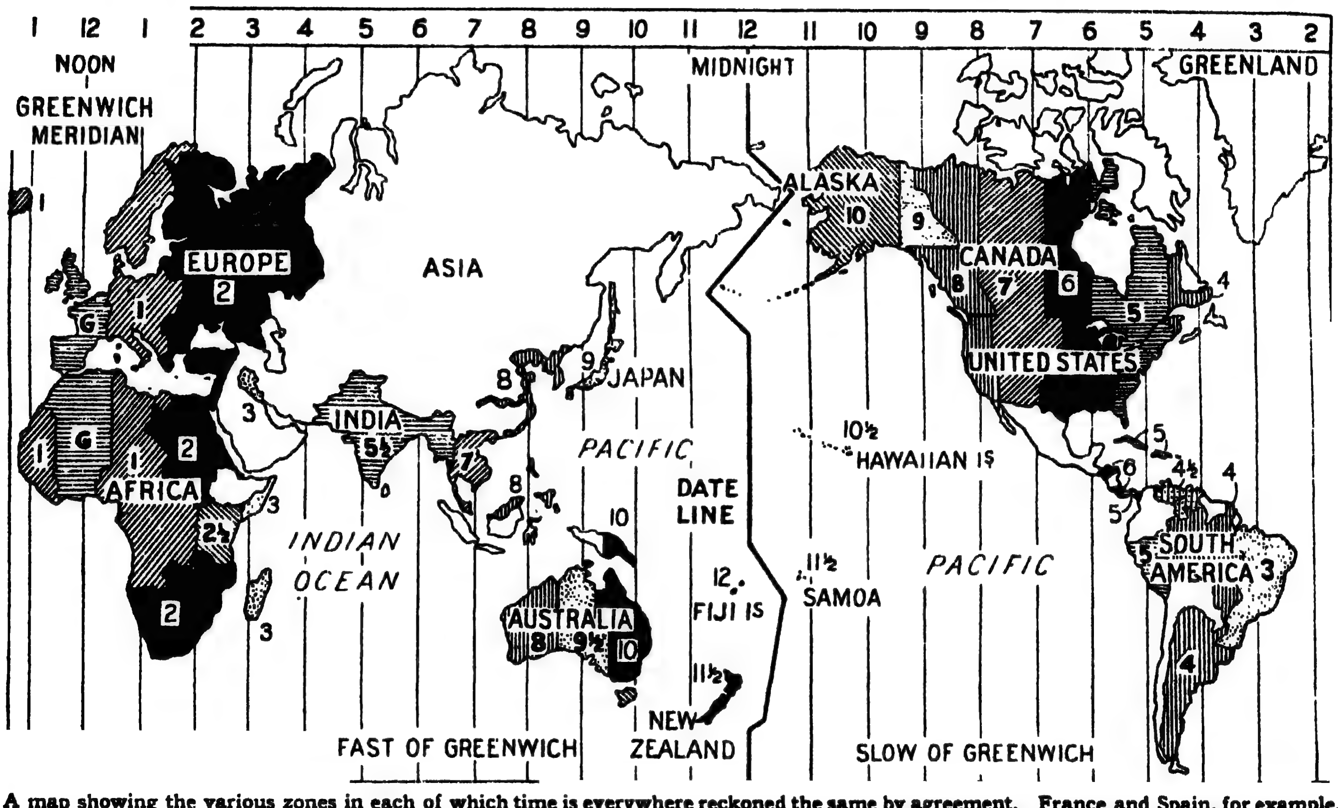
This agreement about a Date Line where each new day and year may be reckoned as beginning is very convenient for mariners as well as for those who live on land. Ships going east and west always adjust their clocks and calendars as they cross this line. This is, of course, necessary, or in the course of time they would be hopelessly out in their reckoning.

A very strange thing may happen to ships in this part of the world. Suppose, for example, two vessels start from London and while one steams east, the other steams west. When they meet at the Date Line the one sailing eastward will be twelve hours in advance of time, while the one sailing westward will be twelve hours behind time. If the two captains compared notes they would find that there was a day's difference in their reckoning. It is clear, therefore, that ships must adjust their clocks and calendars.

Another strange thing that might happen to a man in a ship steaming across the Date Line at the dawn of a New Year is this; he might lie down as the ship crossed the Line, and for a moment have one half of his body living in the Old Year and the other half in the New Year.

Another question may be asked about the New Year: Why does it begin on January 1st? Well, there is no reason why it should begin on this particular date, and indeed it did not always do so, nor does it do so in all lands to-day. In Anglo-Saxon England December 25th, Christmas Day, was also New Year's Day. When William the Conqueror came he ordered that the New Year should start on January 1st, because that was the day arranged for his coronation. Later on England decided that in common with the rest of Christendom the New Year should begin on March 25th, and that was our New Year's Day right down to 1752.

Pope Gregory XIII reformed the calendar in 1582 and made the New Year begin on January 1st instead of March 25th, but England, being Protestant, would not adopt this new calendar for a very long time. In 1752, however, the change was made in England, and it was decided that the New Year should henceforth begin on January 1st instead of March 25th.



A map showing the various zones in each of which time is everywhere reckoned the same by agreement. France and Spain, for example, keep Greenwich Time, as indicated by the G. The figures west and east of Greenwich show hours fast or slow of Greenwich Time

HOW THE SUN WORKS NIAGARA FALLS

Every minute 167 million gallons of water crash over the limestone precipice at Niagara and fall 155 feet into the river below. As the water falls it generates many millions of horse-power, and men, realising that so much power was going to waste, have harnessed about four million horse-power to generate electric light and work machinery over hundreds of square miles. How is all this power produced at Niagara? This picture explains the matter. It is the Sun that works Niagara Falls. Its rays fall upon the ocean, warming the surface, so that evaporation is constantly going on, and the water vapour, being light, rises. The winds carry it till it reaches a cooler region where it is condensed into particles of water, forming clouds. Then, when the clouds get too heavy to float in the air, they fall as rain. The water runs into the river-bed, where it flows towards the sea, pouring over the precipice at Niagara on its way

THE WORLD'S HOTTEST & COLDEST PLACES

Only twice has the shade temperature in the British Isles risen to 100 degrees Fahrenheit, and that was on July 15th, 1881, and August 9th 1911. But in other parts of the world far higher temperatures are recorded. These very high temperatures do not occur on or near the Equator. The highest shade temperature ever recorded is 134 degrees Fahrenheit, and this was on July 10th, 1913, at Greenland Ranch, in the Death Valley, Southern California. The name Greenland was given not as a joke, but because of the green alfalfa which flourishes there. Death Valley is a wide arid area 276 feet below sea level

In contrast to the above picture here is the coldest spot in the world. It is not at the North Pole, but very far from it. The place is known as Verkhoyansk and it is in Northern Siberia. There, on January 15, 1885, the Fahrenheit thermometer registered a temperature of -90.4 degrees or over 122 degrees of frost. It is difficult for those who live in the Temperate Zone to realise what such cold means

WHY A VIOLIN MAKES BEAUTIFUL MUSIC

Everybody loves to hear a good violin played well. Its music is the nearest thing to the human voice that can be produced. Indeed, it simulates every effect of the voice except that of articulate speech. The violin is really a very wonderful instrument, and in these pages we read some exceedingly interesting facts about it

THERE are some people who think that a violin is a very simple sort of instrument, that it consists merely of a kind of box with a handle and a few strings which can be screwed up tight, and that to produce the music all that one has to do is to draw a bow across the strings.

Of course, as a rough description of a violin this is quite true, but a violin is by no means such a simple instrument as the description would suggest

To produce beautiful music it has to be made very carefully indeed of the right kinds of material, and any mistake or carelessness in its construction will spoil the tone and indeed prevent it giving really musical sounds at all So important is it that the violin should be made in the right proportions and of the right materials, that even the varnish which covers the wood makes all the difference in the world.

A Great Maker of Violins

There was a clever maker of violins named Antonius Stradivarius who lived at Cremona in Italy in the seventeenth and eighteenth centuries, and made the most marvellous violins that the world has ever seen. They are called Stradivarius violins after their maker, or for short, " Strads."

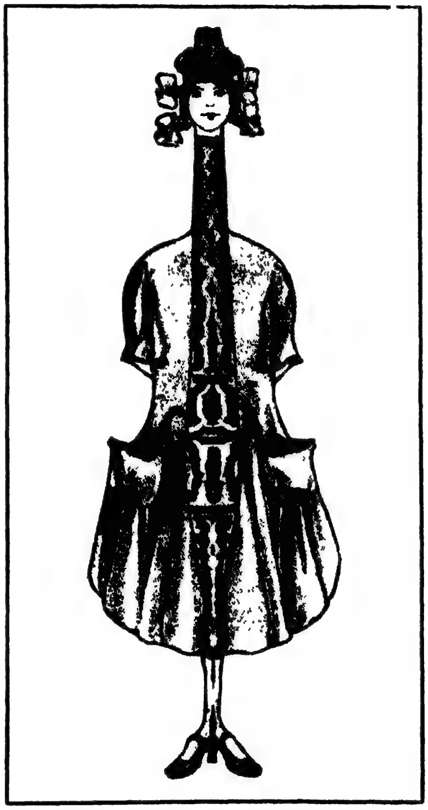
A genuine Strad violin to-day, when put up for sale, realises thousands of pounds, and no violins that have been made since have ever been able to produce such marvellous music as these. Stradivarius was a pupil of another famous violin maker, Nicolo Amati, also of Cremona, and he, too, made wonderful violins that to-day are worth large sums of money.

The Secret of the Varnish

Now, during the last two hundred years men of all kinds—violin makers, scientists, and so on—have studied and examined Strad violins to see if they could discover the secret of their lovely tone, and many of them have come to the conclusion that the secret really lies in the nature of the varnish that Stradivarius used to polish his wood. If so, it is a truly wonderful thing that the tone of a violin should be so improved by the mere composition of the varnish on its outside.

But let us see exactly what a violin is. Probably many people will be astonished to learn that a violin consists of seventy different parts, all of them, except the strings and the loop that holds the tail-piece to which the strings are fastened, being of wood.

The wood used in the making of the violin is not all of one kind. There are at least three sorts—maple or sycamore for the lower plate or back, handle, ribs and bridge ; ebony for the finger-board, nut, screws, tail-piece, and the button at the bottom round which the loop is fixed ; and pine for the upper plate or belly, sound bar, blocks,



Not many people know that the shape of the violin is based on the human form. It has a head, a neck, a body, a back, ribs, and a waist. This fanciful picture shows the similarity of the fiddle or violin to the human form in general design

linings and sound post. What these various parts are we shall soon explain

Swiss pine is said to be the best wood of its kind for the upper plate and was preferred by the old Italian makers. This is on account of its low density which enables the sounds to be transmitted rapidly.

It is important that the wood used for a violin should be in the right condition and for this to be the case the tree must have been cut down at least five or six years so that the wood is well seasoned. On the other hand, the wood must not be so old as to have lost its elasticity, for a great deal of the success of the violin depends upon the wood being elastic.

Even the grain is important, and in the case of the maple and pine there should be a fairly wide and perfectly straight grain. Anything like knots in the wood render it useless for violin making Curves in the grain also spoil the violin, as they make the vibrations uneven when the violin is being played

Copying the Old Masters

The lower plate is sometimes made out of a single piece of wood, but as this is rather wasteful two pieces are usually glued together to form the back. However, the upper plate is practically always in one piece. In making the halves for the back they are not cut to the same thickness throughout Each has a thick and a thin edge and it is the thick edges which are planed perfectly smooth and then glued together so that the thicker part may come in the middle of the violin and the thin edges at the outside.

Most modern makers of violins generally copy the designs of Stradivarius or some other famous old fiddle maker, and it is a fact that the violin is the only musical instrument which has not for more than three centuries changed its shape or form

The Parts of a Violin

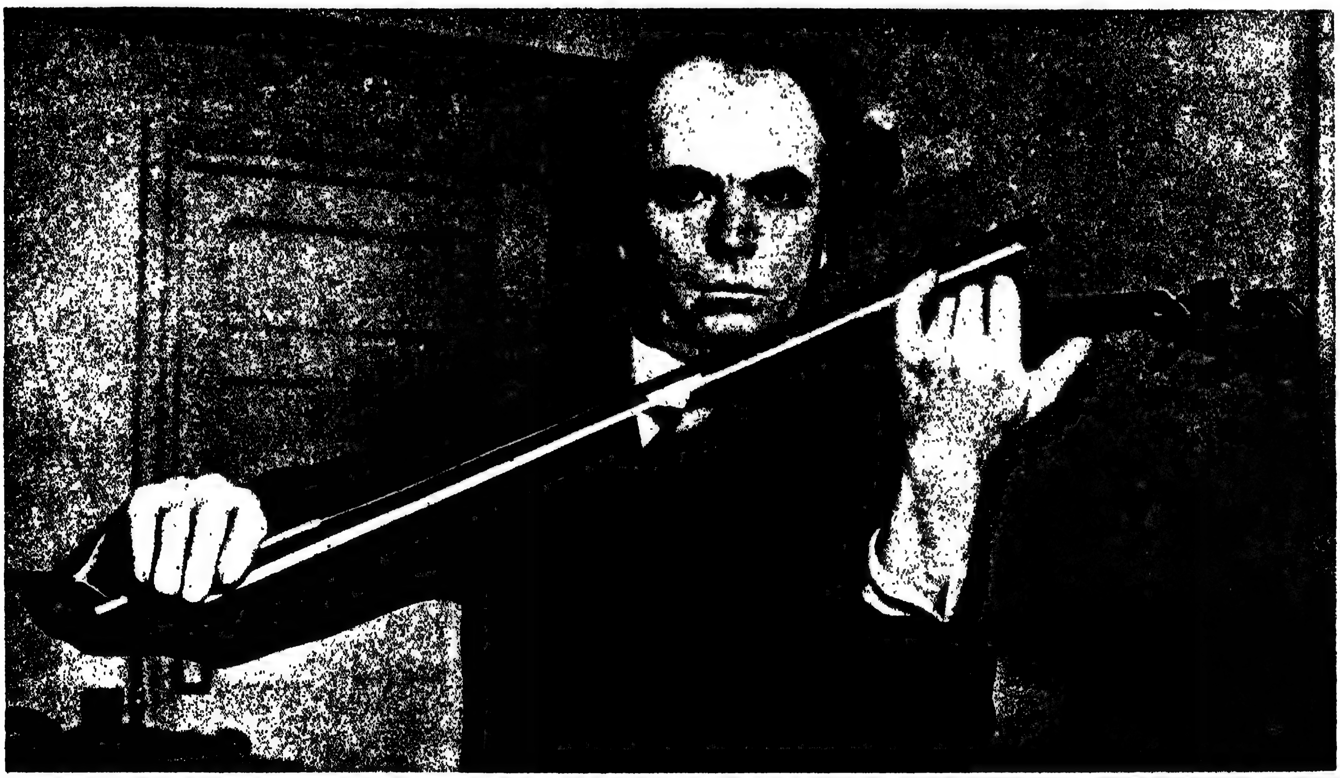
The upper and lower plates are connected together by means of sides or ribs in six pieces and bent to the required form by means of a heated iron, and there are triangular blocks at the angles, at the top and bottom and also along the seam of the back. Then there are linings to the sides in twelve pieces, and a beading or purfling partly of ebony and partly of maple running round the edges of the upper and lower plates. This is in twenty-four pieces.

Inside, between the two plates, there is a bar of wood, elliptical in form, known as a base or sound bar, and this is fixed down the length of the violin and a little on one side of the centre line to strengthen the instrument.

The upper plate is pierced on each side at its narrowest part with two *f*-shaped openings which are called " sound holes " or sometimes " *f* holes." Between the *f* holes is placed a bridge, a small piece of wood with two feet and perforated to make it elastic, and this serves as a support to the

TUNING AND PLAYING THE VIOLIN

The four strings of a violin are tuned to four notes. Other notes are obtained by "stopping" the strings, that is, by pressing upon them with the fingers to shorten or lengthen the part vibrated by the bow, as we see the great master Kubelik doing in the left-hand picture. In order to tune the strings before he begins playing, the violinist tightens or loosens them by turning the pegs at the neck of the violin, as Kreisler, the famous violinist, is doing in the right-hand picture



The violin is played with a bow, a long wooden wand on which are stretched strands of horsehair. These are rubbed over with rosin (that is resin) to make them rough. They are then drawn across the strings of the violin, and the friction between the particles of rosin and the strings of the violin set those strings vibrating and the vibrations cause waves in the air which produce the sounds of music

strings, of which there are four. The bridge has notches to keep the strings from slipping and it is curved so that the strings are not in one plane and can therefore be played individually. They are attached at one end to a tail-piece which, in turn, is fastened to the lowest part of the violin's sides or ribs, by a loop and button. The tail-piece has four holes in it through which the strings are passed and fixed by knots. At the other end the strings rest on a little nut or raised bar of ebony and then enter the hollow part of the violin's head or handle and are wound round pegs.

Between the nut and the bridge of the violin the strings pass over a convex strip of ebony known as the finger board, which is glued to the neck and projects over the upper plate of the instrument without touching it.

Finally, there is one other part of the violin not seen from the outside, which is of very great importance, although it is not very large. It is known as the sound post, and consists of a cylindrical piece of wood fixed vertically so as to connect the upper and lower plates of the violin.

It serves two purposes. For one thing, it gives strength to the violin, and being placed beneath the treble or right foot of the bridge, helps to support the bridge. In the earliest violins one foot of the bridge was lengthened and passed through the upper plate and rested on the back, but that idea soon gave place to a separate sound post.

Then the sound post regulates the pulsations of sound in the violin, and has been described as the "nervous system" of the violin. By altering the position of the sound post the tone of the violin can be made more mellow or more intense though, of course, a badly constructed violin can never be made into a good instrument merely by a sound post

Catgut nothing to do with cats

The head of the violin, that is the part where the strings are wound round the screws or pegs, is carved into the shape of a volute or spiral scroll, which has a double groove on its back. The cutting of this is a very difficult and delicate piece of work.

There are four strings to a violin which are made of so called catgut. Of course, most of us know that catgut has nothing to do with the cat. Possibly in very early days strings may have been made of material from the inside of the cat, although there is no proof of this. The mistake of calling the strings catgut, however, goes on. A more likely explanation of the word is that it was originally kit-gut, meaning gut for a kit or small fiddle used by dancing masters.

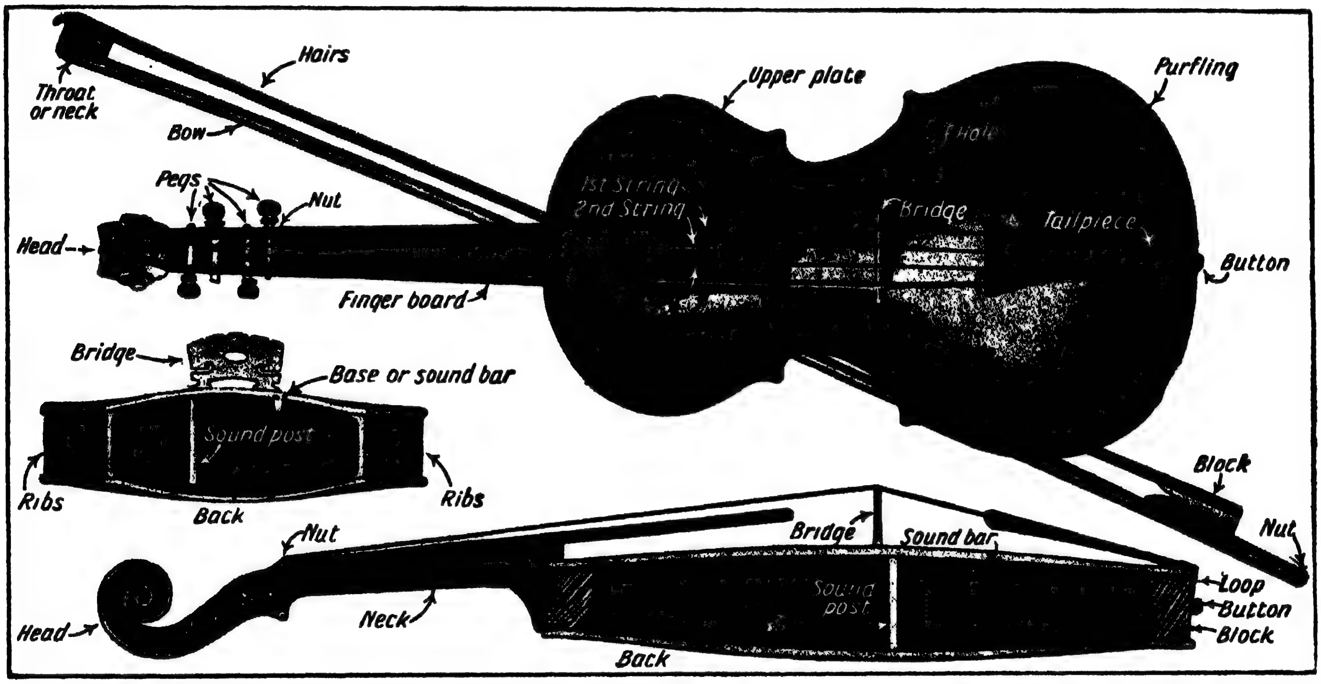
The different kinds of strings

The strings are really made from the intestines of the sheep or goat, generally of the former. The best and strongest qualities are from the lamb. Strings are sometimes made from nylon.

The strings are of equal length, but vary in thickness. The first string, which is the smallest, is on the right side of the finger board as the violin is held for playing, and is spun from a few fine threads of catgut. The second and third strings are thicker, and the fourth, which is thickest of all, is covered with wire so as to give a penetrating and metallic tone

There are several kinds of covered strings. Those with silver wire are very durable and have a soft tone. They are much used on old instruments. Others are covered with copper or copper-plated wire, and these give a more powerful sound, while the covering of others is of mixed wire.

Violins are very much like human beings; they have a personality and no two instruments are quite alike. They cannot, therefore, be strung haphazard, but each violin must be studied and known in order that it may be fitted properly with the kind of strings that will give the best results.



A violin seen from various points of view, with its different parts named. The instrument is anything but simple in its construction, for there are no fewer than seventy different parts, and at least three kinds of wood are used in its making. The sound post is partly for strength and partly to regulate the sound. It has been called "the nervous system of the violin"

By turning the pegs, round which the strings are wound, tension is given to the strings, and it is in this way that the instrument is tuned. Of course, the strain on the strings when they are drawn tight is very great, and were it not for the sound bar and the sound post inside, the upper plate would collapse owing to the pressure of the bridge upon it.

When the violin has been tuned the player holds the instrument between his chin and left collar-bone, resting the neck of the instrument in his left hand in such a way that the fingers can be placed easily on the strings at various distances from the nut.

The violin is played with a device known as a bow, so called because originally it was shaped like the bow with which we shoot arrows. It now consists of a wand of Brazilian lance-

wood or snake-wood from South America, and in its making there are also used ivory from Africa or India, mother-of-pearl from Ceylon, gold from South Africa or silver from America, and hair from a horse's tail, preferably a stallion's, as being stronger.

A great deal depends upon the construction of the bow and the material from which it is made, and this therefore has to be selected very carefully. It is said that the proportion of horse hairs which are suitable for a violin bow are not more than ten per cent. of the total number of hairs produced.

The Bow of Many Hairs

From 150 to 200 hairs are used in a bow At the top of the stick or wand and forming a part of it, is a block or head sometimes called the throat, and by others the neck, of the bow This is generally shaped as shown in the picture of a bow. But the shape is not always exactly the same.

The stick is curved by means of dry heat. At the bottom is a block which can be moved slowly up or down by means of a nut. The hairs are fixed in the throat or neck like a ribbon, and then stretched tightly, the other ends being attached firmly to the moving block below. They are drawn tight by means of the nut.

The hairs are then resined and the violin is played by drawing this bow across the strings, vibrating them so that they set up waves in the air and cause musical sounds. The different notes are obtained by the player pressing the fingers of his left hand on the strings at various points. In this way the playing or vibratory part of each string is made longer or shorter.

But sometimes the strings are struck with the wood of the bow to give a drum-like effect, and at other times the strings are plucked with the fingers, the effect being something like that of a guitar.

It is interesting to know why the hairs of the bow are resined. Horse hair, examined through a microscope, is seen to have its surface covered with minute scales which, in the ordinary way, lie close to the shaft of the hair When, however, resin is rubbed along the hair small particles of it get fixed under the scales causing them to stand up so that the hair is something like a very fine fretsaw with tiny teeth along its length. It is these erected scales passing along the string of the violin when the bow is drawn across it that act as so many little plectra and give a series of rapid shocks producing the sustained sound which we know so well in violin playing.

The Need for Resin

A bow that has not been resined produces no sound, for instead of giving a series of shocks to the violin string it merely exerts continuous pressure and prevents any vibration at all. There are ivory faces on the throat or neck of the bow, and metal is used not only for ornamentation but for the weighting of the bow The mother-of-pearl is purely for ornament.

It is interesting to realise that all three kingdoms, the animal, the vegetable, and the mineral, have contributed their parts to produce a violin bow.

The length of a violin is fixed by the length of the average human arm bent at a convenient angle, and the length of the handle or neck is determined by the space that the human hand can cover with the fingers. The curious shape of the violin body, with its curves going in on either side, is for the purpose of allowing the player to draw the whole bow easily across any of the strings. If there were not these curves the bow could not pass right down the outside strings on either side.

It might be thought that a long, narrow sound box uniform in width the whole way would be suitable. This would enable the bow to be used properly, but owing to the length of the sound box the tone would be spoiled. Everything, indeed, in a violin has been thought out most carefully, and is the result of years of experience.

How the Sound Comes

When the violin is played the strings are vibrated. The vibration is communicated to the upper plate of the violin by means of the bridge, and is then passed on to the under plate by the sound post. In this way the sound is greatly increased and comes out into the air by means of the *f*-shaped holes in the upper plate.

The violin, with its near relations the viola, violoncello and double bass, all of which are constructed on the same principle, is the most important of all the instruments in an orchestra, as can be seen in the list of instruments in a really large orchestra. At one of the Handel Festivals, for instance, the band consisted of 93 first violins, 72 second violins, 56 violas, 58 violoncellos, 57 double basses, or a total of 336 stringed instruments of the violin family, while other instruments formed a very small part of the band. There were only 33 wood-wind instruments, 38 brass instruments, and 8 drums, making a total of 415 instruments altogether.

The next time we see the violin being played it will be worth while to remember what a marvellous instrument it is and what a romantic history it has had.

A TOY THAT TEACHES A SCIENTIFIC PRINCIPLE

We have read a good deal in this book about centrifugal force, and what it does. The force is explained fully in the section that begins on page 61, and we understand that when a body is whirling round, anything that may be loose on its surface will be hurled off at a tangent, that is, in a straight line from the circumference.

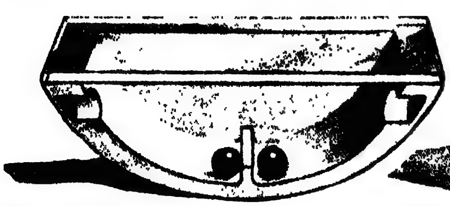
The toy that is shown in the pictures below is a very interesting object lesson in centrifugal force.

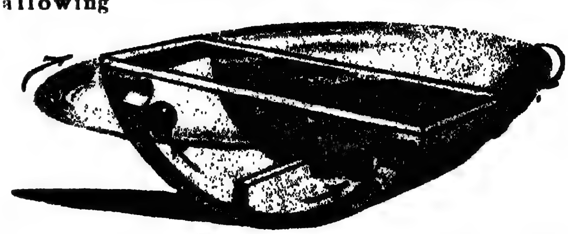
In a small enclosed case of the shape shown, with a glass top and sides, are two small metal balls, and these are free to move anywhere inside the case. At the bottom of the case is a raised division separating the curved part into two equal halves, and this division runs right across the case. At each end of the curve near the glass cover, and to one side, is a small recess large enough to hold a ball. The problem is to place the two balls in the two recesses.

A person who does not understand the toy, at once tries to manage the business in the way shown in the middle picture, that is, by getting one ball in first and then by very carefully tilting the case to get the second ball into its recess, without allowing the first one to fall out. Of course, such a manœuvre is quite useless. The ball already in always comes out when the case is tilted.

The person who understands the little apparatus does not go to work in this way at all.

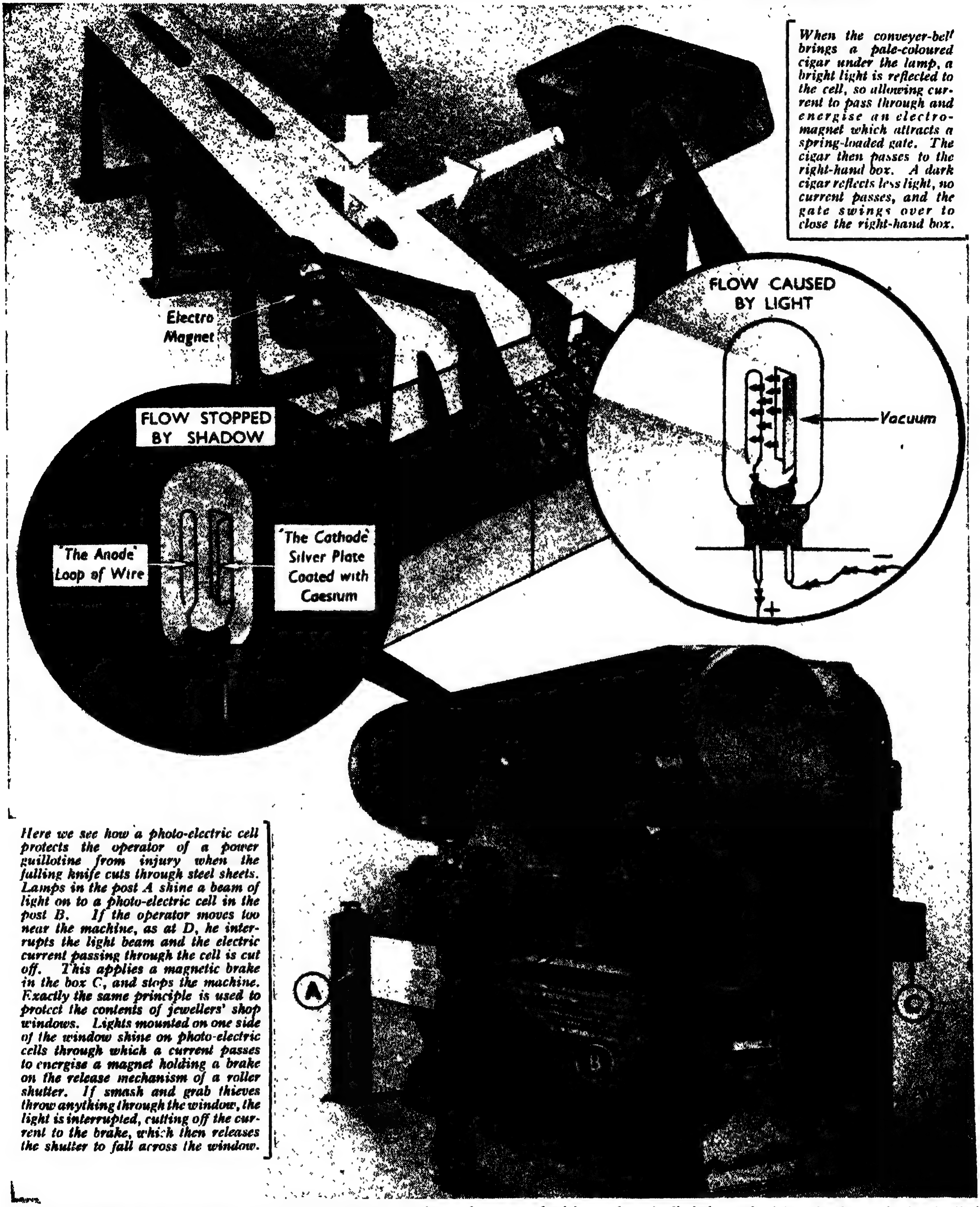
Knowing the principle of centrifugal force, he simply takes the little case in his two hands and spins it round rapidly on the table like a top. At once, moved by centrifugal force, the two balls try to fly off, but as they cannot get out of the case they fly into the little recesses, and when the spinning case comes to a standstill they are both in the right positions.





This little toy is an excellent teacher of science, for it shows in a very striking way the principle of centrifugal force. The two balls seen in the first picture have to be placed in the two recesses, one on each side. This cannot possibly be done by careful balancing, as in the second picture, for when trying to put the second ball in its recess, the first ball slips out. The task is accomplished by spinning the case rapidly, when the balls rush into their respective places by centrifugal force

HOW LIGHT IS MADE TO DO WORK



When the conveyer-belt brings a pale-coloured cigar under the lamp, a bright light is reflected to the cell, so allowing current to pass through and energise an electro-magnet which attracts a spring-loaded gate. The cigar then passes to the right-hand box. A dark cigar reflects less light, no current passes, and the gate swings over to close the right-hand box.

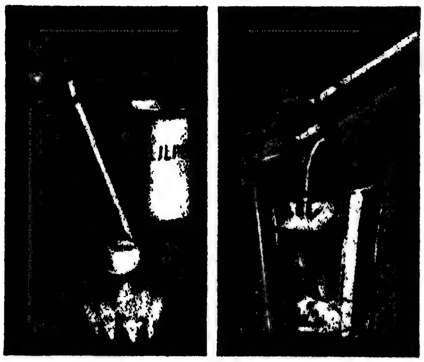
Here we see how a photo-electric cell protects the operator of a power guillotine from injury when the falling knife cuts through steel sheets. Lamps in the post A shine a beam of light on to a photo-electric cell in the post B. If the operator moves too near the machine, as at D, he interrupts the light beam and the electric current passing through the cell is cut off. This applies a magnetic brake in the box C, and stops the machine. Exactly the same principle is used to protect the contents of jewellers' shop windows. Lights mounted on one side of the window shine on photo-electric cells through which a current passes to energise a magnet holding a brake on the release mechanism of a roller shutter. If smash and grab thieves throw anything through the window, the light is interrupted, cutting off the current to the brake, which then releases the shutter to fall across the window.

In its most simple form, a photo-electric cell consists of a silver plate coated with caesium (called the cathode) and a loop of wire (called the anode) which are placed in a vacuum tube like that of a radio valve. Both are connected externally to a source of electric supply, but because of the empty space between them no current can pass from anode to cathode. If, however, a light shines on the cathode, electrons are released from it and a current will flow from one to the other. If the light is interrupted, the path is broken and the current stops. This phenomenon is used for the automatic control of a variety of devices, two of which are illustrated above

EXPERIMENTS WITH SULPHUR AND LIME WATER

There are many interesting experiments we can perform at home with sulphur. This element takes various forms, as we shall see.

First of all, let us take a small quantity of the ordinary roll sulphur which is in the form of a hard stick. We crush the sulphur to a powder and put it in a test-tube. Then, by means of a holder which we can make for our-

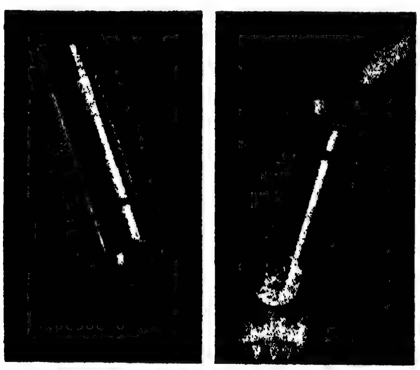


Roll sulphur heated over a gas-ring becomes amber-coloured, but when poured into cold water returns to its original form

selves by twisting a piece of wire, we hold the test-tube in the flame of a gas-ring.

The sulphur melts, and is no longer the light yellow of its roll form, but becomes dark, like amber. While it is melted at this stage let us pour a little into a tumbler of cold water. The sulphur at once cools and turns into ordinary sulphur again.

Now let us hold the test-tube in the flame of the gas-ring once more. It gets



When more heat is applied the sulphur becomes too thick to pour, but if heated still further it gets thin and gives off vapour

darker and darker and assumes the consistency of thick treacle, so that if we turn the test-tube upside-down the sulphur will not run out.

We continue the heating and, curiously enough, the sulphur becomes thin once more, and soon it begins to boil, when it gives off a vapour of an orange colour and then cools into a fine powder which we call flowers of sulphur. If some of the boiling sulphur be poured from the test-tube into cold water it will undergo another change and become what is known as plastic sulphur, an elastic substance which can be bent like india-rubber.

Let us take some of this plastic sulphur and leave it for a few days exposed to the air. When we come to it we shall find that it has changed once more to ordinary sulphur.

Next let us try an experiment which will result in our making a chemical compound out of chemical elements. We put a little powdered roll sulphur in a test-tube with a few copper filings or turnings on top and then hold the test-tube in the flame of a gas-ring. At once the heat causes

The hand dipped into water keeps dry

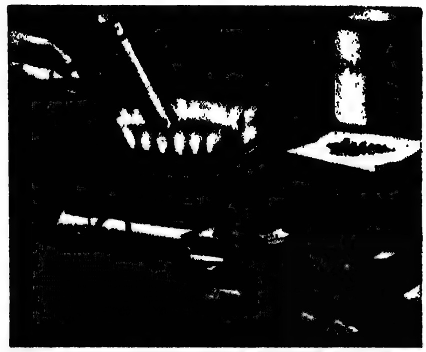
certain physical changes to take place in the sulphur and the copper. The sulphur melts, becomes dark, and boils, and the copper turnings also melt.

But these physical changes are not the only ones that occur. A chemical change also takes place, for if we remove the test-tube and, after it is cold, break it, we shall take from it a black substance and find neither sulphur

The clear lime water that becomes milky

nor copper. The black matter is the chemical compound copper-sulphide.

Still another interesting experiment with sulphur will help us to do a little bleaching. We take a glass jam-jar and find a cork that will seal it completely. Through the cork we stick a wire and on the end of the wire tie some coloured flowers and ribbons. Then we place in the bottom of the jar a small dish of burning sulphur. When the sulphur is in position we cork up the jar. The fumes from the burning sulphur are sulphur-dioxide gas, a chemical compound formed by the oxygen of the air in the jar combining



When sulphur and copper turnings are heated together a black compound results known as copper-sulphide

with the sulphur, under the action of heat. These fumes have the power of bleaching the flowers and ribbons.

Now for a change let us do two experiments not connected with sulphur. We are going to be able to dip our hand into water without wetting it. We get at the chemist's a small quantity of lycopodium powder, which consists of the dry spores of a fungus This powder we rub well over our hand before plunging it into the water. Now when we dip our hand into the

The fumes from burning sulphur in a closed jam-jar will bleach coloured flowers

fluid we find it comes out quite dry, because there is no cohesion between the lycopodium powder covering our hands and the particles of water.

The final experiment is to prove that there is carbon-dioxide gas in the atmosphere of a room in which people are breathing. We put a saucer of clear lime water on the floor. In a short time it is no longer clear, but has become milky. The carbon-dioxide in the air has changed the lime of the lime water into chalk, giving the milky appearance.

THE MARVELLOUS ROMANCE OF THE FIG

The fig does not seem a very romantic object, but in all the annals of plant life there is no greater romance than the life story of a fig, and here we read how the great secret of fig culture was discovered by men of science

When you eat a dried fig and find it pleasant you little realise the romance that centres round it. For there seems nothing very romantic about a box of figs, yet the life story of the fig you eat is one of the great wonder stories of Nature.

The figs we eat are known as Smyrna figs, though they are not all grown in or around Smyrna. They often come from California and from various Mediterranean countries. But they are called Smyrna figs to distinguish them from wild or caprifigs. The name caprifig means "goat fig," and was given because the goats of the East feed on the wild fig plant.

Now from very ancient times it has been known that good ripe figs of an excellent flavour were only found on the Smyrna fig trees when there were caprifigs growing in the same places. Nobody knew why this was, although it was believed that a little insect that used to be seen coming out of the caprifigs had something to do with it.

This insect, which is really a little wasp, had been seen to make its way into the Smyrna figs hanging on the cultivated trees, and it was thought that for these to come to maturity it was necessary that they should be perforated by the little wasp. There was truth in this, but why, no one could say until quite recently, when patient men of science found out the whole story.

A Mysterious Custom

Though they did not know the reason for the fact, fig growers in the East always carried out what was described by the term "caprification." This consisted in cutting off branches of the wild fig trees containing caprifigs and tying them above the branches of the cultivated fig trees bearing Smyrna figs. Something mysterious then happened, and beautiful luscious figs resulted on the Smyrna fig trees, which could be eaten fresh, or dried in the sun and kept for future food supplies.

Now some years ago a number of business men in America, realising that large quantities of dried Smyrna figs were imported into the United States from the East, thought that it would be a good idea, as they had such a fine rich fruit-growing soil and climate in California, to grow their own figs. They therefore imported some trees and planted them. In due course figs appeared, but they were wretched little things and would not dry properly. They had no flavour, and dropped off the trees.

"Ah," thought the business men, "the trees we imported were of poor stock. We must get better trees." So they sent away to the East and obtained fresh plants.

Those who went to the East learnt the curious idea which the natives had that it was necessary to suspend over the Smyrna figs, when they appeared, branches of caprifigs in order that the edible figs might be large and luscious. They therefore took with them to California some caprifig plants, and these were planted in the same orchards as the Smyrna figs. Still only little figs appeared, withered and dropped off.

A fig tree heavily laden with ripe fruit, a proof that the blossoms have been fertilised by little wasps from a caprifig or wild fig tree. Unless these wasps carry pollen from the male flowers of the wild fig to the female flowers of the cultivated fig no fruits form

HOW A LITTLE WASP GIVES US LUSCIOUS FIGS

The life story of the figs which we eat is one of the great romances of natural history. The figs we see growing on a tree in England are not really the fruit at all but the flower, for the flower has the same outward shape as the fresh fruit The fig blossom is really like a daisy or dandelion with its many florets curled round so that the florets all point inwards. For this strange flower to produce fruit it is necessary that the female flowers of the Smyrna or edible fig be fertilised with pollen from the male flowers of the caprifig or wild fig. This fertilisation is carried out by a little wasp which spends its winter inside the autumn crop of caprifigs and, after emerging in spring, enters the spring caprifigs to lay its eggs. It dies, but its children as soon as they hatch out leave the caprifig, carrying with them pollen, and they then bore their way into the Smyrna figs, where the pollen is rubbed off, fertilising the female flowers. The wasp comes out and flies off, and when the summer caprifigs appear it goes inside and lays eggs. These hatch, and the young wasps emerge, and after a time enter the autumn caprifigs to spend the winter. Meanwhile, the Smyrna figs have developed into fine, luscious fruits

The matter was investigated, and soon it was decided to make an experiment. Pollen was taken from the caprifig flowers and placed in some of the Smyrna figs. These at once showed a remarkable change. They developed and became fine and luscious fruits.

Here, then, was the beginning of an explanation. In the next season more Smyrna figs had pollen placed in them from caprifig blossoms by means of little glass tubes, and they also ripened and became fine fruits.

It was obvious, however, that if large crops of good figs were to be produced in California it would be far too costly to pollinate every one by hand from a wild-fig blossom. There must be some natural way by which the pollen from the wild figs which seemed to be so necessary for the development of the Smyrna figs could enter the latter. Men of science became very interested, and it was not long before they found out the whole romance of the fig.

It seems that the wild or caprifig plants have three crops, one coming in spring, another in summer and the last in autumn. The autumn caprifigs remain on the tree all the winter.

Now little wasps enter the autumn caprifigs and live inside them all through the winter months. Then when spring comes round once again they come out, and finding the new spring caprifigs on the tree they make their way into these and lay eggs. Then they die, but after a time fresh wasps hatch out of the eggs inside the spring caprifigs, and these soon come out.

But before going on any farther with the story we must explain the make-up of the fig flower. Some of us have fig trees in our gardens, and in the summer figs appear on these. We say the tree is in fruit, but these pear-shaped growths that look so much like fruits are not fruits at all, but flowers.

The Curious Flowers of the Fig

We all know how a daisy or dandelion is made up of a number of florets arranged round a centre. The fig blossom that looks so much like a fruit is really a flower of this type. Yet how different it looks! Let us take one of the so-called "figs" from a fig tree and cut it down the middle lengthwise. Inside we can at once see a large number of florets. Some of these are male flowers and some are female flowers. The fig blossom is really something like a dandelion or daisy head with all the florets gathered up and curled inwards. The male and female flowers are on the same plant.

When the little wasp is hatched from an egg in a caprifig it lives on the food which it finds there till this is exhausted and then it comes out. But in order to make its exit it must pass among the male flowers of the caprifig and it becomes covered with pollen from them. It reaches the open air and, flying about looking for a new home in which to lay eggs, it is deceived by the Smyrna figs hanging on the cultivated trees. As the ancients noticed, it pierces the edible fig blossom, thinking this is a caprifig, and enters, but soon discovers its mistake and comes out again.

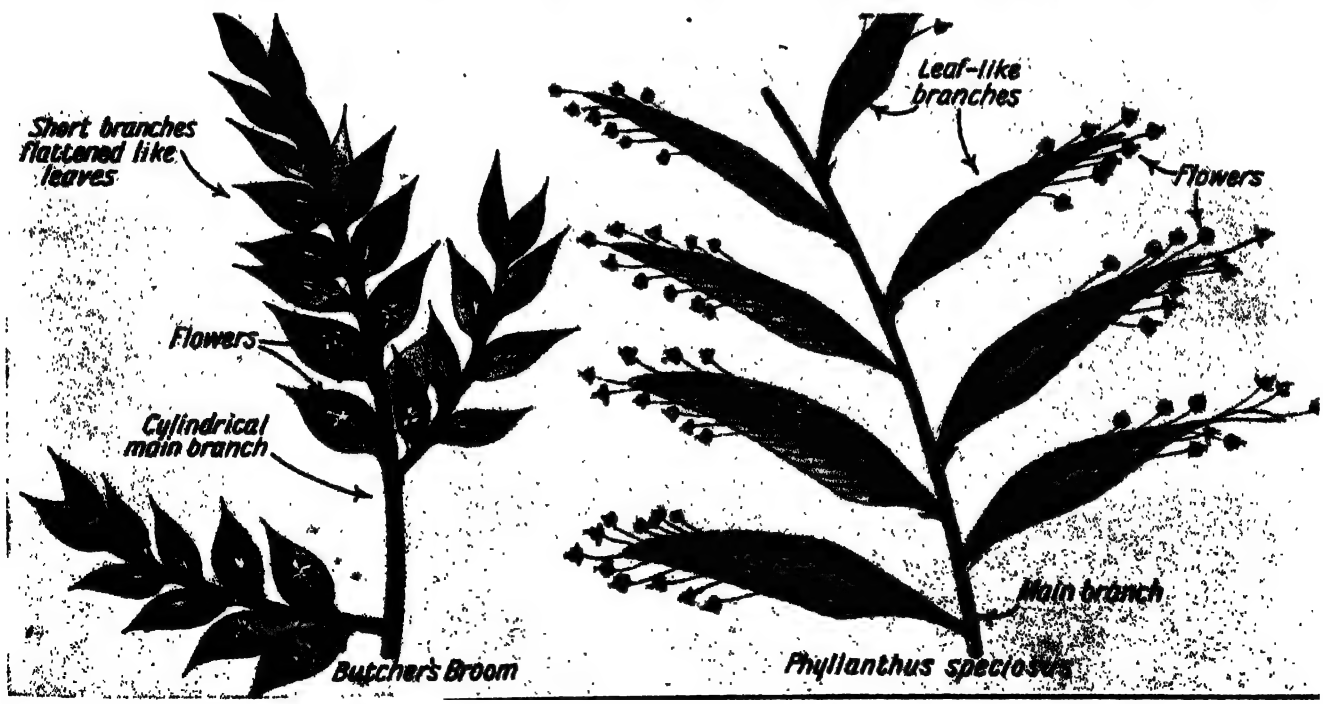
During the journey inside the cultivated fig blossom, however, the pollen has become brushed off the wasp's back, and falling on the female flowers inside the fig causes these to develop so that seeds are produced, and the fig, though retaining outwardly very much the same shape, is now no longer a flower but a fruit.

The work the Smyrna figs need has been done by the little wasp, but the wasp is not yet finished. It must lay eggs if its race is to be carried on, so it flies about till some time later the summer caprifigs appear on the wild fig trees. Here is what it wants as a home in which to lay its eggs.

It goes inside. The eggs are laid, and after the food supply is exhausted new wasps come out of the summer caprifigs and find the autumn caprifigs on the trees, into which sooner or later they go to spend the winter. Then the whole story starts all over again.

Once the life story of the Smyrna fig, the caprifig and the wasp had been discovered it needed only care and patience to produce luscious Smyrna figs in California. Several attempts were made, and at last the wasps were carried across the Atlantic, and now in California a large crop of fine edible figs is produced every year.

PLANTS WITH BRANCHES THAT LOOK LIKE LEAVES



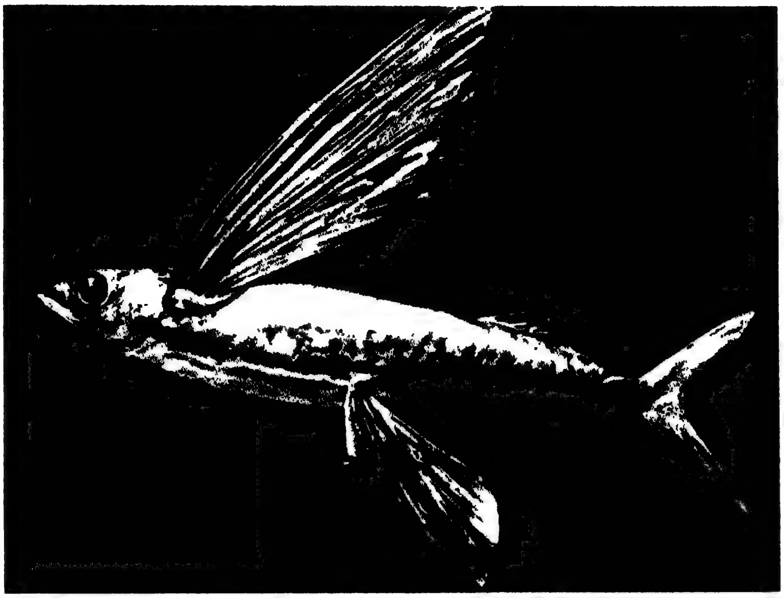
In some plants like the familiar Butcher's Broom, shown here on the left, and the Phyllanthus, shown on the right, a strange thing happens, for the short branches on the stems become flattened so that they look like leaves. They are called by botanists cladodes, a name which comes from the Greek word "klados," meaning "a branch." Why the branches of these plants should have developed in this curious leaf-like form it is difficult to say, but as we can see, although they look like leaves they still behave like stalks, for small scale-like leaves spring from them as they do from the branches of other plants, and from the axils of the scales arise stalked flowers

THE FLYING FISH AND ITS ENEMIES

The flying fish is not a flier at all in the sense that a bird is a flier. It is really a glider. When it jumps from the water it spreads out its pectoral or breast fins, which are developed into a great size, and glides sometimes for 500 feet or more. The flight is rapid, but gets slower towards the end, though at its height the fish will race a ship going at ten miles an hour.

The fish can fly farther against the wind than when it is travelling with it or at an angle. When it takes a turning or zigzags, this is not due to any effort on the part of the fish, but is caused by the currents of air. In calm weather the line of flight is direct, and in form like the course of a projectile, but in rough weather the flying becomes undulating.

In the Atlantic and elsewhere—for the flying fish is found in many waters—the creature often falls on the decks of vessels. When the fish leaves the water it is almost invariably because an enemy is pursuing it.

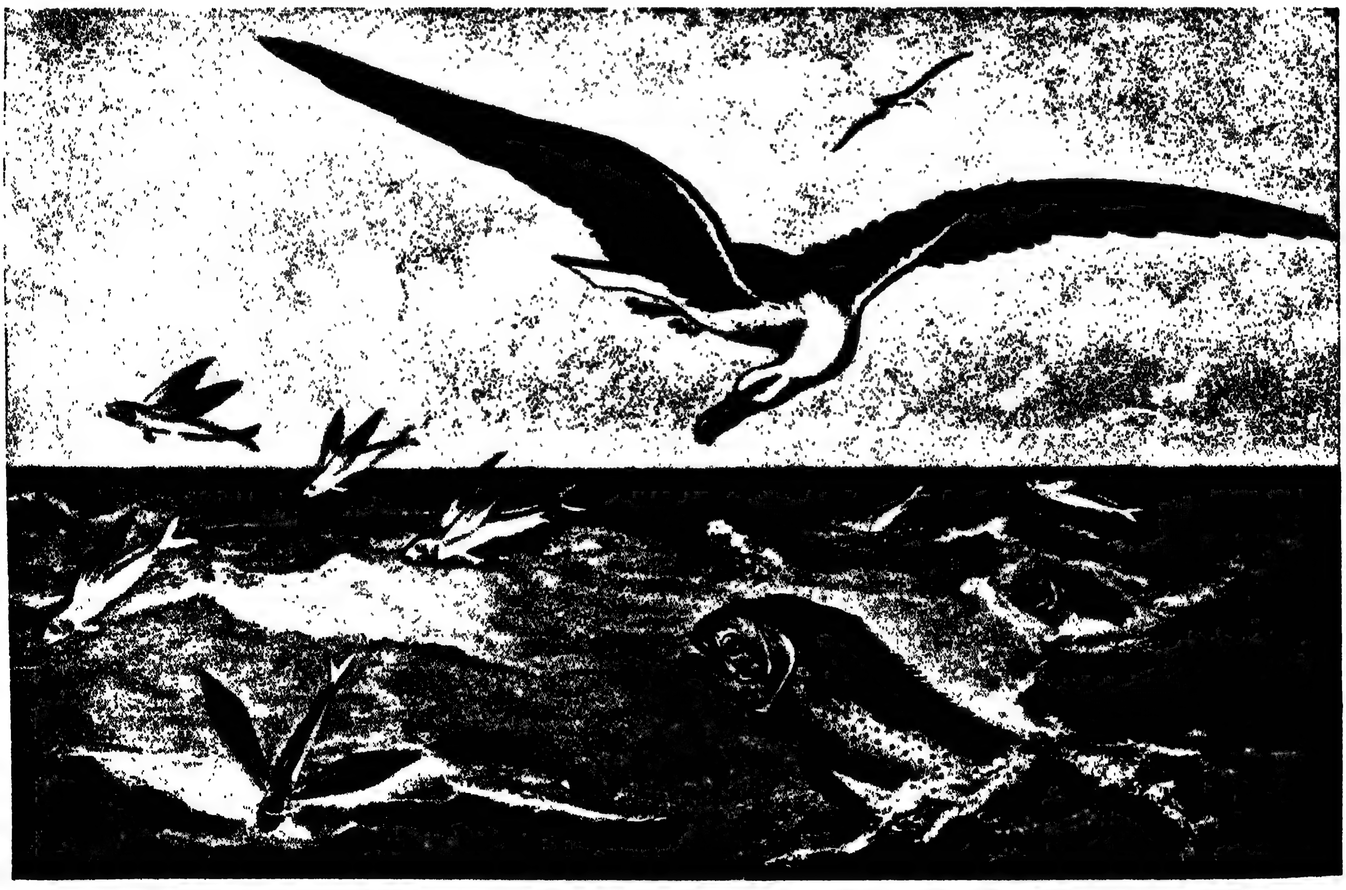


The flying fish as it appears when in full flight

At such times a number of flying fish will rise from the water and begin their gliding flight, and not only do their spread fins vibrate as though they were making a real effort to fly, but their tail is often seen to work vigorously something like a screw.

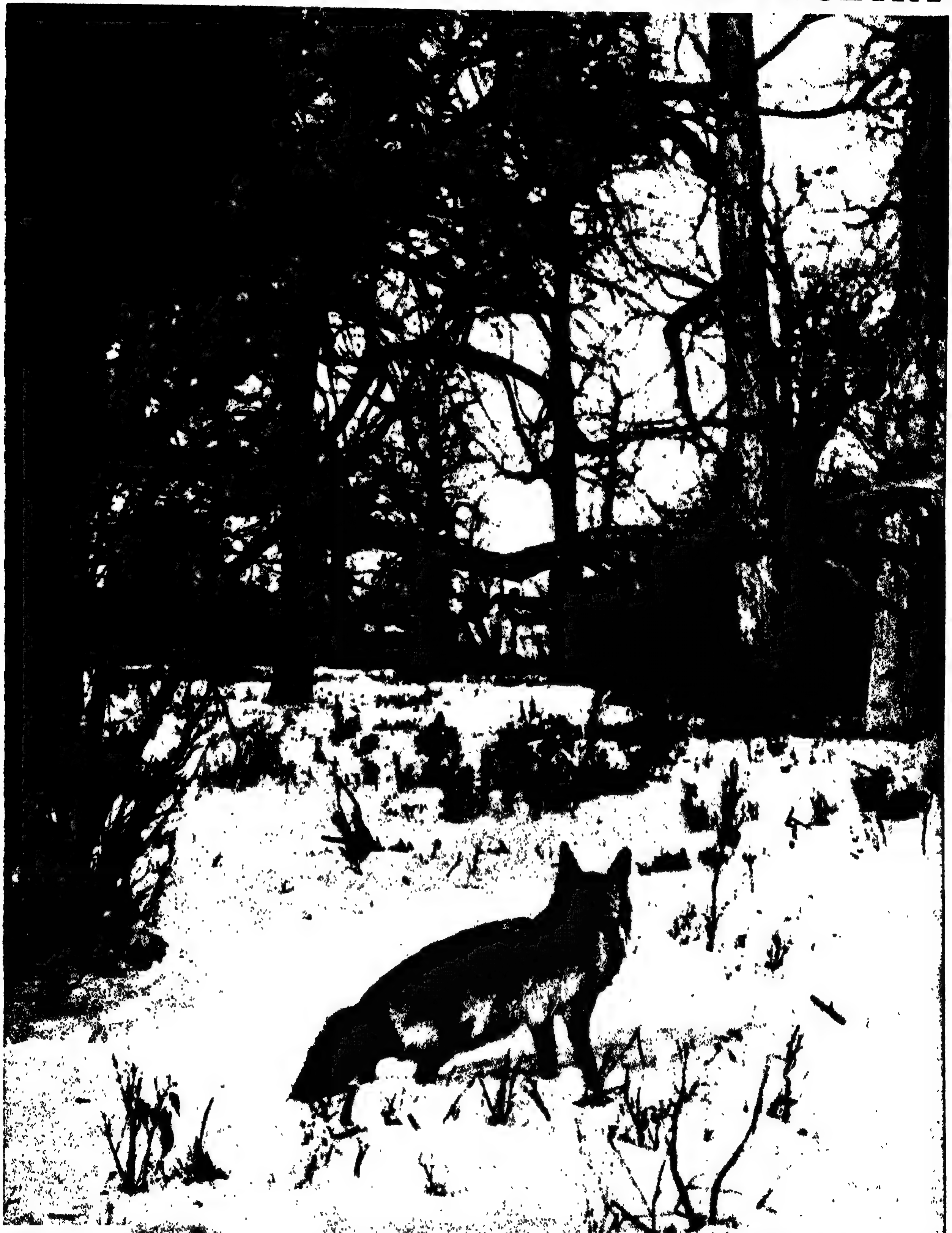
In a gale, flying fish have been seen to rise as high as the top of a ship's mast. Sometimes they dart through cabin windows.

There are several species of fish that fly in this way. The flying gurnard, also found in the North Atlantic, particularly near the Sargasso Sea, is an interesting fish, for its head is protected by a heavy, thick armour, so that it is able to strike a considerable blow without hurting itself. Its side fins, when spread, form great parachutes, and the fish, being richly coloured with red, blue and yellow hues, looks like a large butterfly.



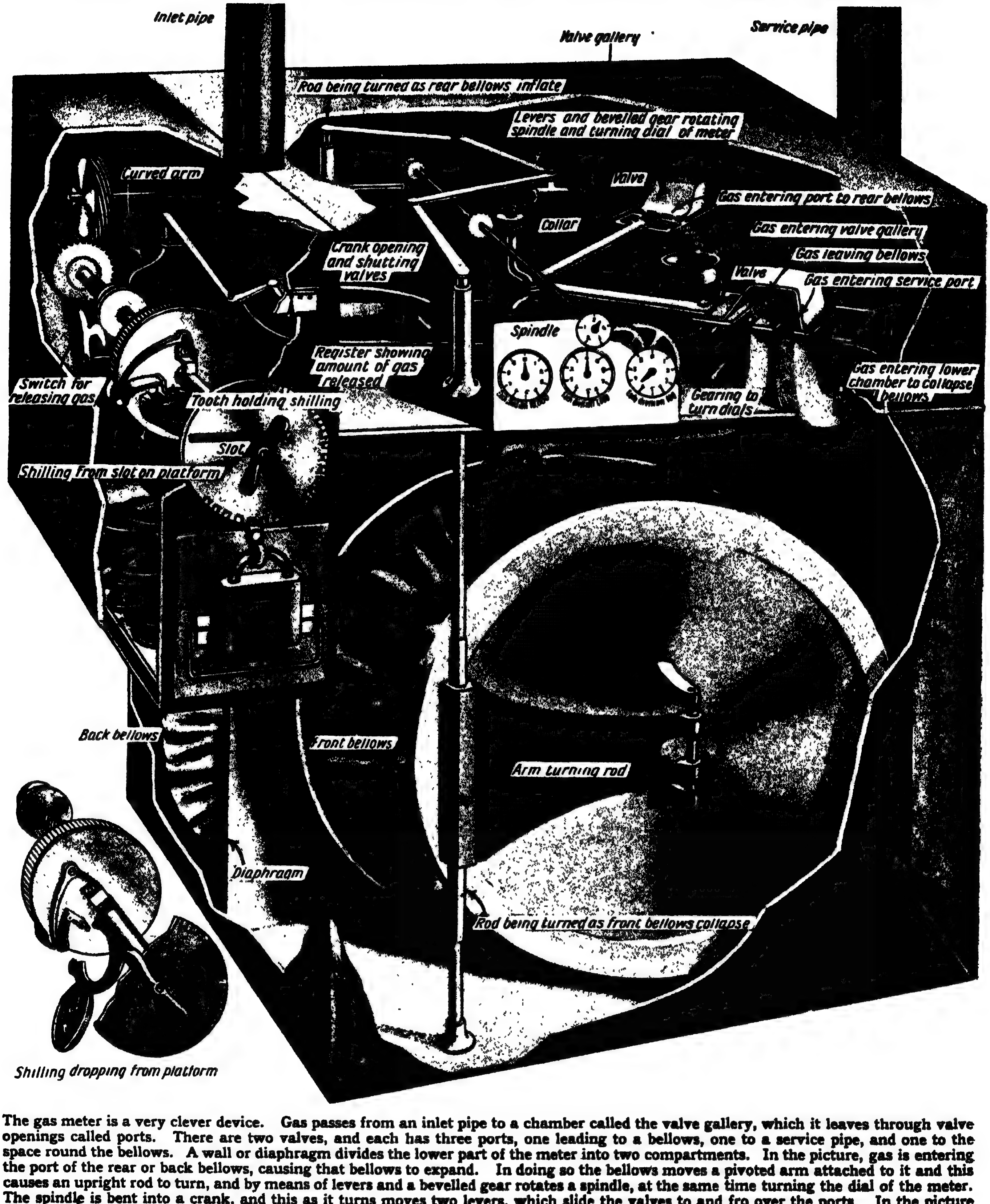
The flying fish, found in the Atlantic and other seas, has a bad time, for it has many enemies, in both water and air. It is pursued by voracious fish like the catfish and by sea mammals like the dolphin. When hunted by these creatures it leaps out of the sea and makes its flight, but the albatross and other birds are waiting to devour it there. Here we see the flying fish escaping from pursuing catfish, only to be hunted by the albatross. The flying fish is a silvery, large-eyed creature somewhat resembling a herring

THE PRAIRIE WOLF LOOKS OUT FOR POULTRY



The coyote, here seen looking out for poultry on a Canadian farm, is the wolf of North America. It is often called the prairie wolf, and it is found from Costa Rica to Hudson Bay. It is smaller than the wolf and has thicker and longer fur, and a more bushy tail. Its colour varies, being a bright tawny brown in summer, turning to grey in winter. It is less savage and destructive than the wolf, and if captured young will become quite a docile pet. Generally it is a solitary animal, but at times it hunts in packs. It is omnivorous, that is, it eats almost everything, and when animal food is not available it will turn vegetarian and make a meal of juniper berries or even prickly pear. Its usual food, however, consists of hares, rats and young birds. It never attacks man unless it is cornered

THE WORKS INSIDE A SLOT GAS METER



The gas meter is a very clever device. Gas passes from an inlet pipe to a chamber called the valve gallery, which it leaves through valve openings called ports. There are two valves, and each has three ports, one leading to a bellows, one to a service pipe, and one to the space round the bellows. A wall or diaphragm divides the lower part of the meter into two compartments. In the picture, gas is entering the port of the rear or back bellows, causing that bellows to expand. In doing so the bellows moves a pivoted arm attached to it and this causes an upright rod to turn, and by means of levers and a bevelled gear rotates a spindle, at the same time turning the dial of the meter. The spindle is bent into a crank, and this as it turns moves two levers, which slide the valves to and fro over the ports. In the picture the front valve is pulled to the left, allowing gas in the bellows to pass through the service port into the service pipe for use in the house. While this is happening gas flows from the inlet pipe into the space outside the bellows, and its pressure causes the front bellows to collapse and empty. The back bellows then fills and operates, and so they go on working alternately. A shilling placed in the slot falls on a platform where it is held by a tooth, and when the handle is turned the shilling drops and a rod moves a switch, which lets a certain quantity of gas into the meter, a curved arm and levers registering the amount

MARVELS of MACHINERY

THE METER THAT MEASURES THE GAS

There are some very ingenious devices in our homes, but as we are unable to see what goes on inside them we often have no idea of their ingenuity and romance. One of the cleverest of these is the gas meter, which registers in cubic feet the amount of gas we use. Everyone should be able to read a gas meter, although now the gas companies charge not so much per thousand cubic feet as they used to do, but so much per therm, which is the heating value of the gas. Here are some interesting facts about the gas meter

INVENTION begets invention, and as soon as coal gas came to be used for domestic purposes and houses received their supplies from the gas works, it became necessary to have some correct and automatic way of registering the amount of gas used in each home.

The first kind of meter devised was invented by a Mr. Clegg, who was engineer to a gas company, and it was known as a wet meter, or water meter.

Wet and Dry Meters

In this type of meter there is an outer case half filled with water, and a drum divided into four compartments revolving inside. These compartments fill first with water and then with gas in turn. When the gas enters it drives the drum round and as the drum turns the gas from the gas-filled compartments passes out through a pipe into the house for use.

But the inconvenience of the wet meter is that it must have the water kept at a certain level, and as water evaporates it needs constant attention. This set men trying to devise a meter that could work without water, and success was attained by Mr. John Malam, who produced a dry meter which was later gradually improved and is the meter in use to-day. It is a triumph of mechanical ingenuity. Its operation can be seen on the opposite page.

The principle is that two bellows work alternately, filling with gas and emptying in turn, and as they collapse and expand they work certain mechanism that by means of levers and spindles, turns the dials of the register, showing how much gas has been used.

Of course, without some apparatus that would measure accurately the amount of gas received and used, it would have been impossible for the manufacture and supply of gas to have become the great industry which it is to-day. The gas-works must know how much is used for the purpose of charging.

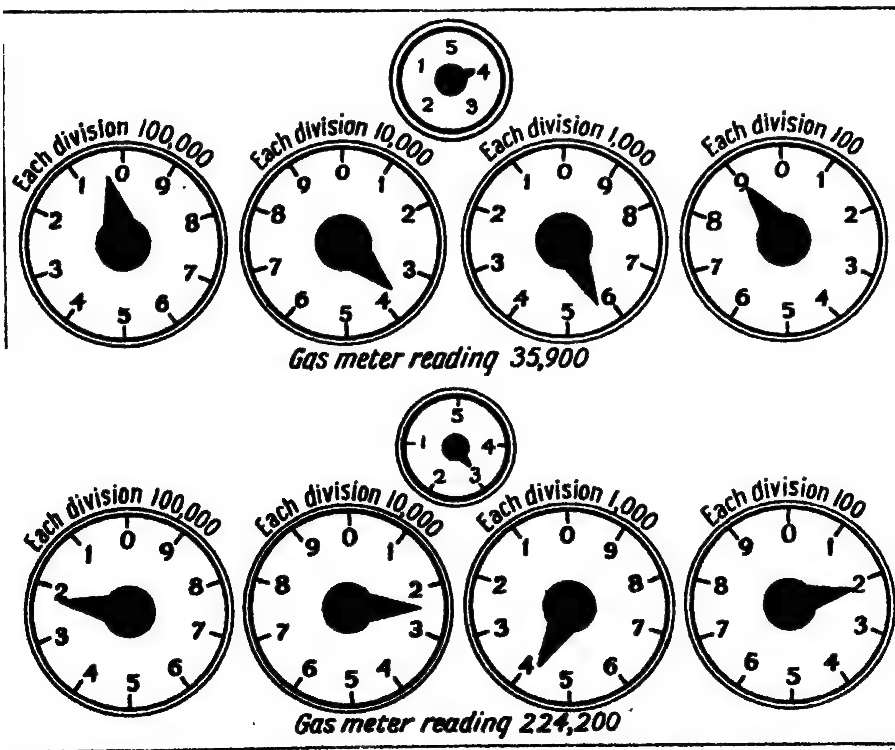
As it is, gas meters are marvellously accurate and very rarely go wrong. They are sealed up and if there is ever a dispute between the gas company and the consumer, either party can insist upon an official examination of the meter, and the party which is proved to be wrong has to pay for this examination. But considering how many millions of consumers there are in the country, it is astonishing how few complaints are ever made and how little dispute there is about the meter.

In these days when gas is charged not at so much per 1,000 cubic feet, but at so much per therm, it is interesting to note what a therm is. The gas therm is 100,000 British Thermal Units, and the British Thermal Unit is the amount of heat required to raise one pound of water one degree Fahrenheit.

The Blessings of Good Lighting

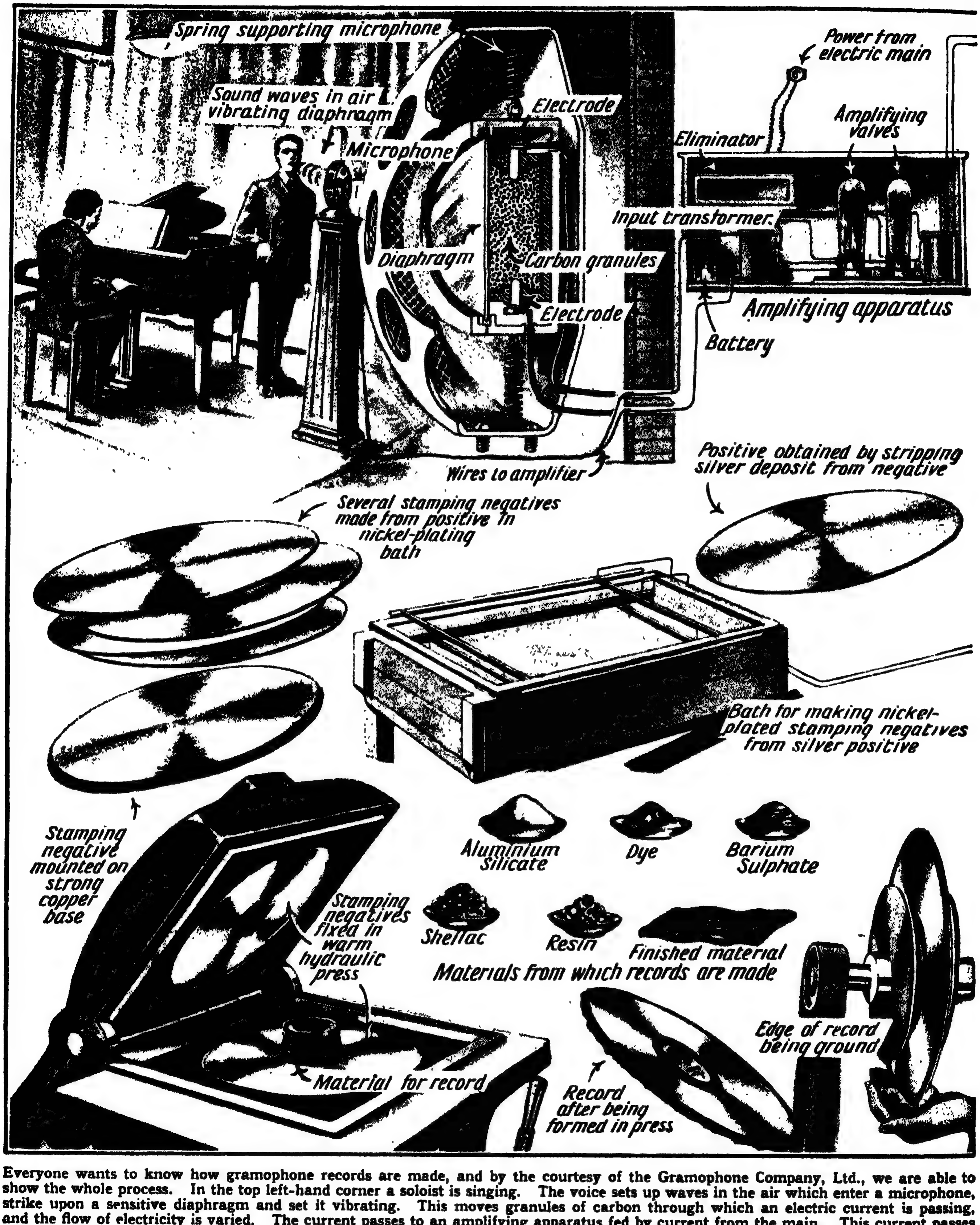
Few people, if they were asked to name the half-dozen greatest boons and blessings among the discoveries and inventions of the last 150 years, would place gas in their list Yet a writer said in 1829, soon after gas came into use for lighting the streets, "What has the new light of all the preachers done for the morality and order of London, compared to what has been effected by gas lighting ?"

There is a world of truth in the old saying, "Everyone who doeth evil hateth the light, neither cometh to the light lest his deeds should be discovered" The words, of course, originally referred to moral light and darkness, but they are equally true of physical light, and nothing did more to suppress crime and evil in the streets of cities and towns after sunset than the improvements in street lighting which came with gas.



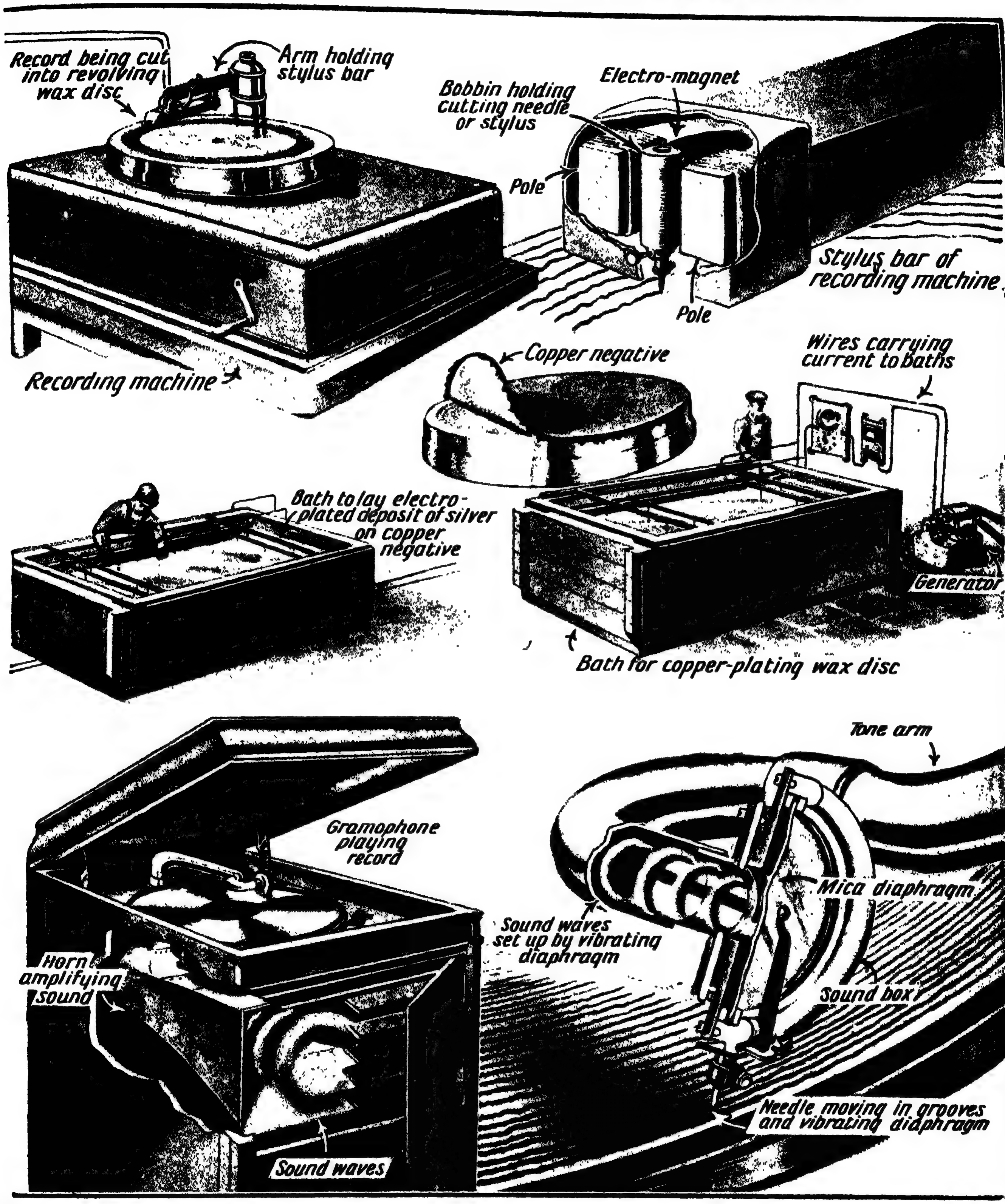
We should all be able to read the gas meter, and here we can see how to do so. The small dial is for marking the passage of single feet of gas through the meter and is only intended to indicate that the meter is working, or to show when all the lights are off that there is no escape of gas. It is by the four large dials that we read the amount of gas consumed. In the right dial each division marks 100 cubic feet, in the next 1,000 cubic feet, and so on. In each dial we take the figure last passed, and starting at the left-hand dial of the upper set write down 0. Then for the second dial we write down 3, for the third 5, and for the last 9, with two o's afterwards for the hundreds. The reading is thus 35,900 cubic feet. The lower line of dials is supposed to indicate the reading when it is next taken, some months later, and here it is 224,200. By subtracting the top reading from the bottom reading we find that the quantity of gas consumed in the period has been 188,300 cubic feet

HOW A GRAMOPHONE RECORD IS MADE



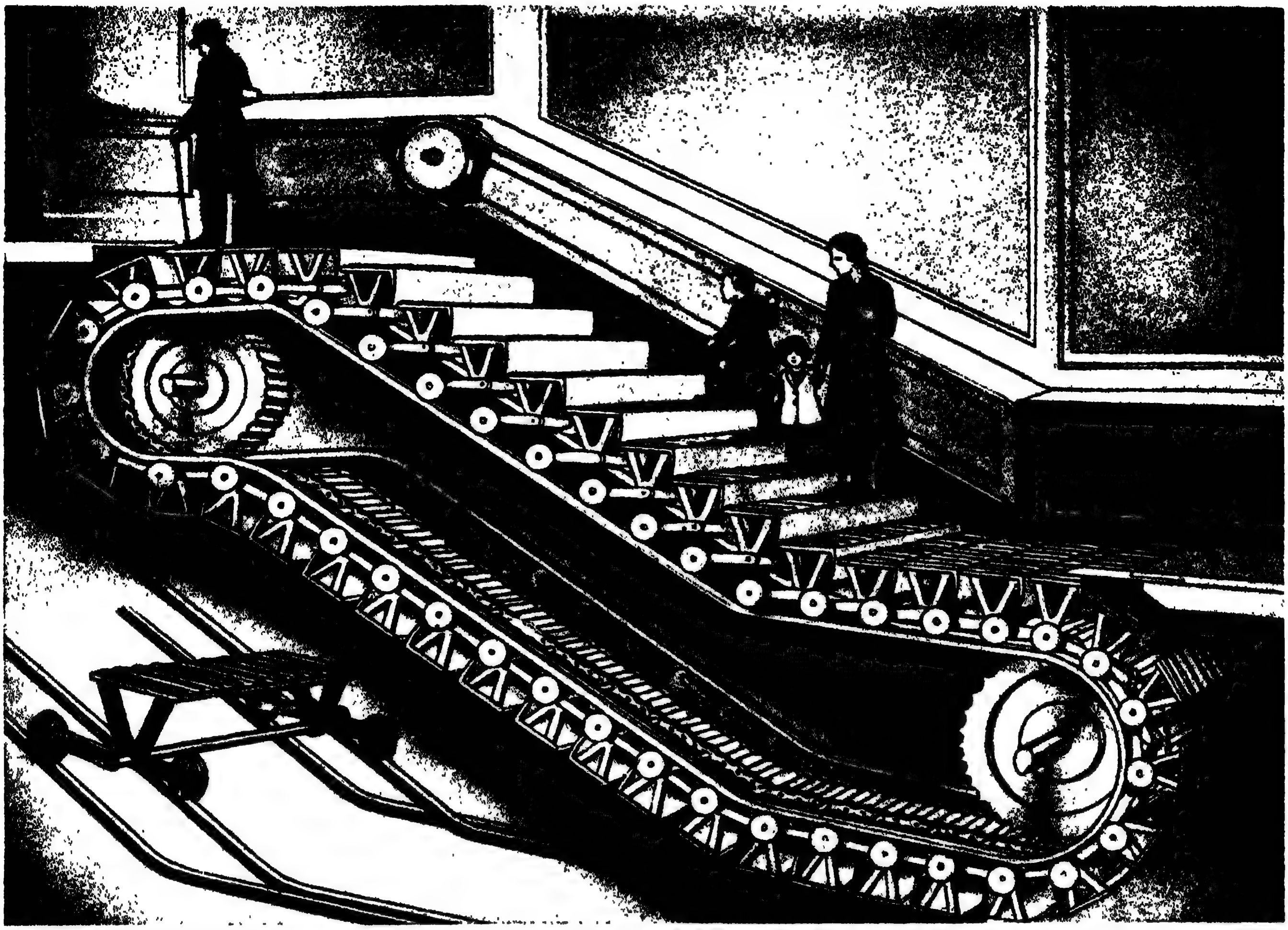
Everyone wants to know how gramophone records are made, and by the courtesy of the Gramophone Company, Ltd., we are able to show the whole process. In the top left-hand corner a soloist is singing. The voice sets up waves in the air which enter a microphone, strike upon a sensitive diaphragm and set it vibrating. This moves granules of carbon through which an electric current is passing, and the flow of electricity is varied. The current passes to an amplifying apparatus fed by current from the main. This current passes through an eliminator which smooths out any jerkiness. From the amplifier the current passes through wires wound round the poles of a magnet on which is a stylus bar, these being on a recording machine. The variation in the current from the microphone causes a bobbin to move to and fro as shown in the enlarged picture of a stylus bar. Attached to the bobbin is a stylus or cutting needle, and as the bobbin moves, this needle cuts a groove in a revolving wax disc. When the song is finished it has been recorded by a continuous wavy line. The wax disc is now placed in an electro-plating bath and is plated with a coating of copper to form a negative of

AND THE HUMAN VOICE REPRODUCED



the record. The copper negative is placed in a bath and coated with silver, and this silver deposit, when stripped off, is a hard replica of the wax disc. The silver is now placed in a bath and plated with nickel, the nickel, which is afterwards taken off, forming a negative from which the actual records are stamped. Two stamping negatives are placed in a warm hydraulic press, and in the centre between them is put a plastic mass of material made up of the five substances shown. The press is then brought down, the material is squeezed out, and the wavy lines on the negatives are impressed on the material, one negative stamping one side and the other the other side. The black record is removed, and its rough edge ground smooth, when it is ready to reproduce the sound originally recorded in the studio. When we place the record in the gramophone the needle is inserted in the wavy line, and as the record goes round the needle waggles to and fro and sets up vibrations in the mica diaphragm of the sound box, which in turn causes waves in the air. These are amplified in the gramophone, and when they strike our ear we hear exactly the sounds that were emitted by the singer in the studio

WHAT AN ESCALATOR IS LIKE UNDERNEATH



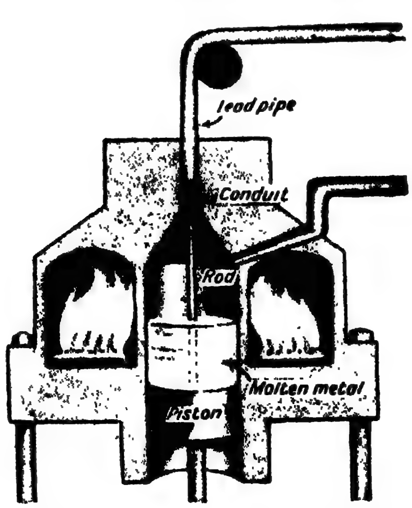
This picture shows how an escalator works. Each stair consists of a flat tread fixed to a metal frame, and this is carried on a truck with two wheels at each side. The wheels are out of line with one another and run on separate parallel rails, so that there are four rails. These rails are first horizontal, then slant upwards, and again become horizontal, curling round and returning below. The whole of the stairs, which are linked together, are moved by an endless chain in the centre, working round two large cogwheels, one above and one below. The treads of the stairs at the bottom form a continuous horizontal plane as long as they are on the horizontal part of the rails. Then when the rails slant up the wheels adjust themselves, and each tread rises gradually with its framework till it becomes a stair. It goes up in this form till at the top, when the wheels pass from the inclined part of the rails to the horizontal once more, the treads arrange themselves as a horizontal plane, and carry us off to the stationary floor. A moving handrail at the side helps nervous people to keep their balance. One of the stairs with its wheels on the rails is shown enlarged in the bottom left-hand corner

HOW LEAD PIPING IS MADE FROM MOLTEN METAL

An enormous amount of lead piping is used as it is the cheapest form of piping for carrying water to different parts of buildings. The great mains which convey the water underground through the streets of a city are made of iron, but the smaller pipes are of lead.

Lead was one of the seven metals known to the Ancients, and articles made of it have been found in Egyptian tombs. The metal is mentioned in the Old Testament, as when Moses sang of the Egyptians lost in the Red Sea that "they sank as lead in the mighty waters."

The lead used in manufacture is obtained chiefly from the mineral galena, which contains sulphur, and generally has a certain amount of zinc, copper and other metals in it—even silver and gold at times. It is found abundantly in the United States, Australia and Spain.



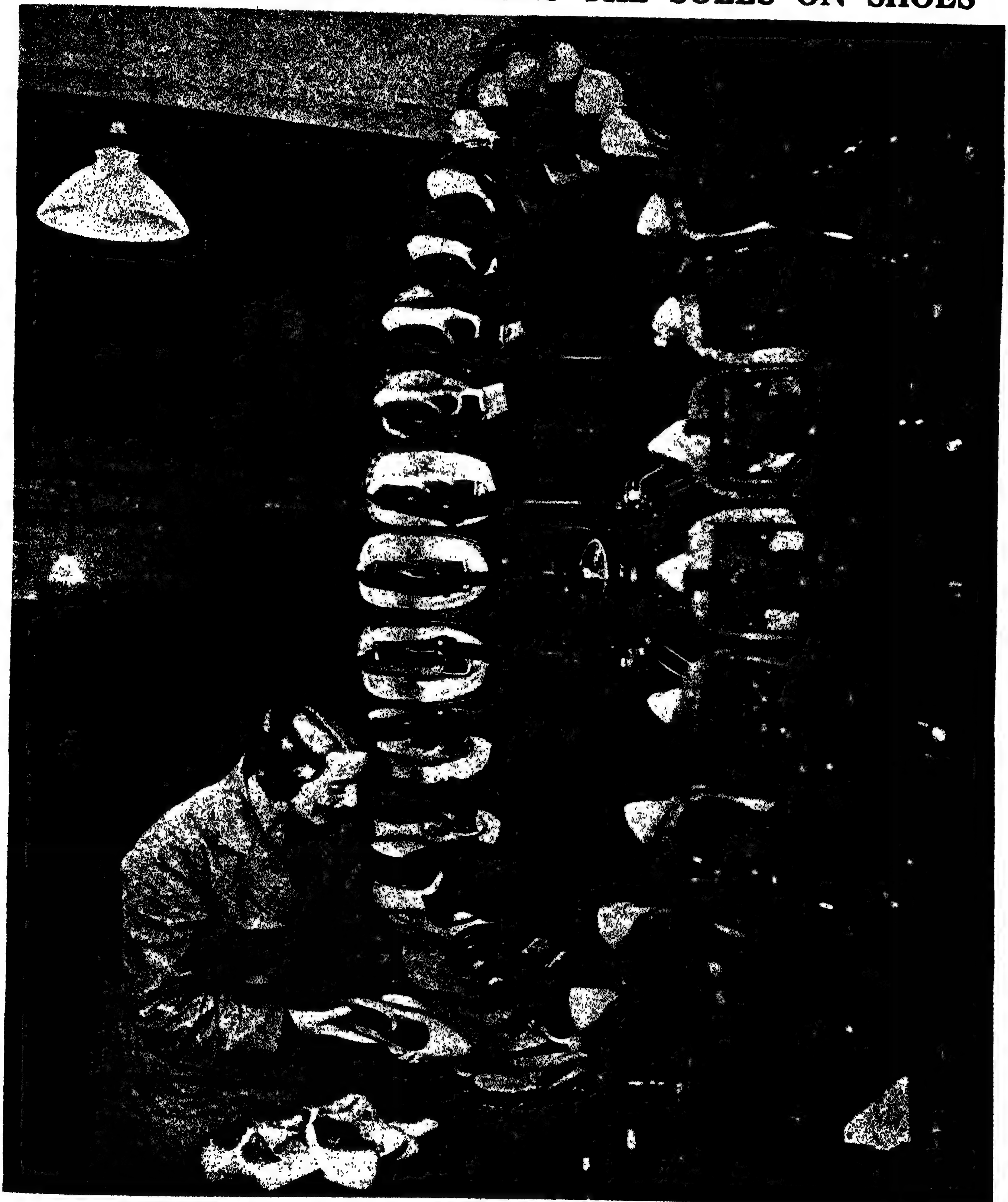
The apparatus that makes lead piping

The galena is melted in a blast furnace and the lead drawn off in moulds, after which it is refined by melting it down once more and stirring with a jet of steam. Lead is an easy metal to work with, as it is soft and melts at 327 degrees Centigrade, or 620·6 degrees Fahrenheit.

The picture diagram here shows how lead pipe is made. Molten lead is passed into a chamber in which stands a steel or iron rod, fixed to a piston. The piston works by means of hydraulic pressure, and when it goes up it carries with it the rod and drives enough of the molten metal round this into the conduit to form the lead piping. The piping comes out and soon cools, passing over a roller, when it is detached and carried away. The softness of lead enables it to be rolled and bent.

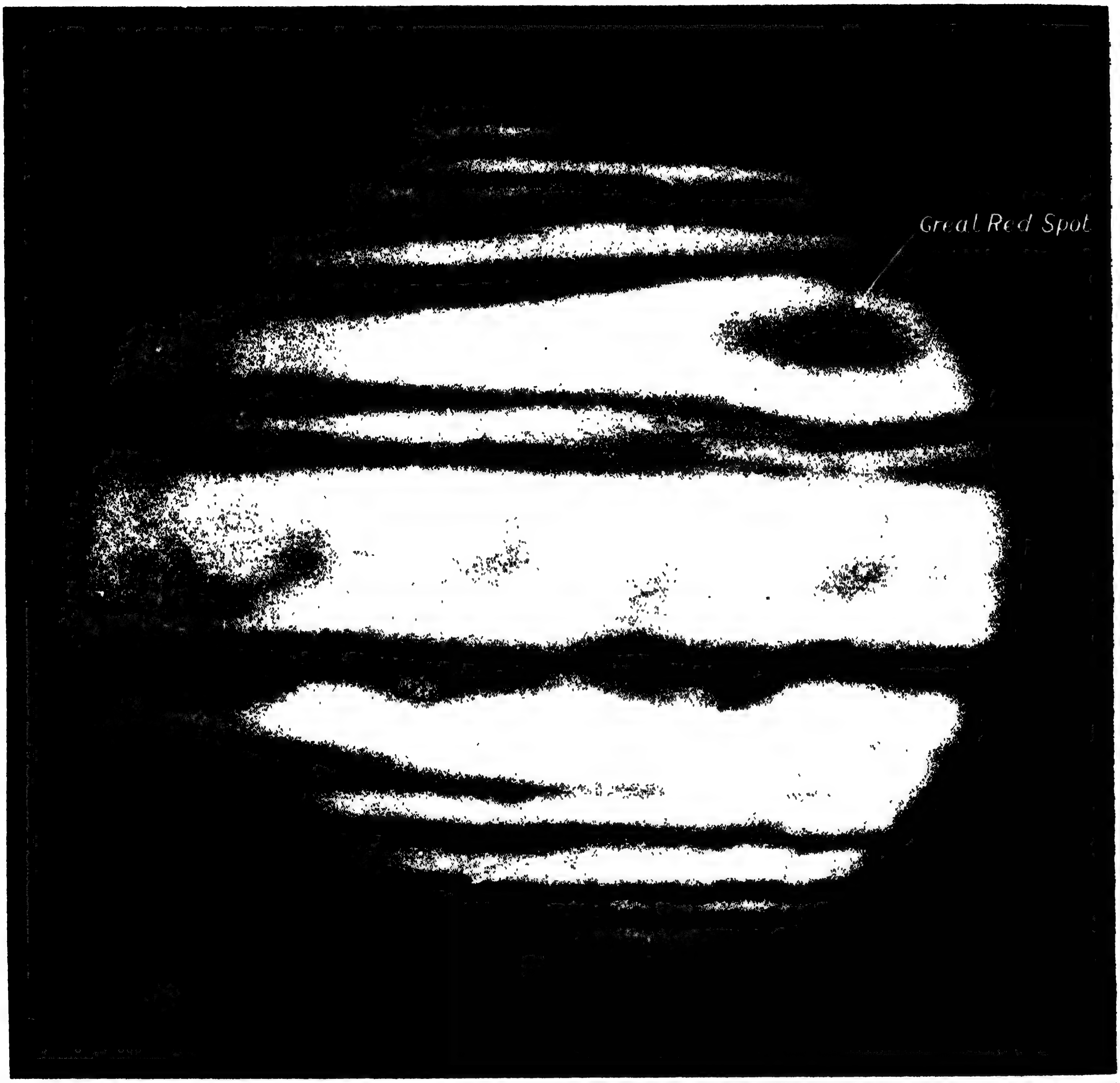
Furnaces round the chamber containing the lead keep the metal in a fluid and workable state.

THE MACHINE THAT STICKS THE SOLES ON SHOES



No industry has more ingenious or intricate machinery than that of the boot and shoe manufacturer. Here is one of the very latest machines used in this industry. It is known as the endless sticker, and it sticks the soles on shoes, this method being used instead of stitching. The machine revolves at a considerable speed and as it goes round the operator puts the shoes in their places and the machine does the rest. Something like 2,000 soles can be stuck on shoes in this way in an hour, and naturally the effect is to cheapen the price of shoes. Of course, a machine of this kind costs a great deal of money to make, but once made its maintenance is not expensive. Labour-saving devices like this may displace workers for a time, but the difficulty often rights itself by an increased demand for cheaper goods

JUPITER AND HOW IT SHOWED THE SPEED OF LIGHT



Jupiter, shown here, is the biggest of all the planets. It is 90,000 miles across at the Equator, and 1,350 Earths could be packed inside this giant world. Indeed, all the other planets of the solar system could be put inside Jupiter, and still there would be space to spare. The bands seen across the planet's surface are supposed to be due to masses of cloud, probably of carbon-dioxide gas. The Great Red Spot, which varies in length and is sometimes 30,000 miles long, is a mystery. Astronomers cannot explain it

This diagram shows how the speed of light was first measured. In 1675 Olaus Romer, a Danish astronomer, studying the eclipses of Jupiter's moons by the planet, noticed that after six months a moon appeared to be about 16½ minutes behind time in arriving at the position C. It suddenly dawned on him that while at one observation the Earth had been in the position A in its orbit round the Sun, six months later it was at B, which was about 186,420,000 miles more distant from Jupiter. The rays of light from Jupiter's moon had had to travel this distance farther, and, thought Romer, the light must have taken that much longer to reach the Earth. Thus he calculated that light travelled at 186,420 miles per second. This was confirmed by later experiments, described on page 115

WONDERS OF THE SKY

THE EARTH'S BIG BROTHER

The giant of the Solar System is the planet Jupiter, which circles round the Sun with his train of eight moons, between the orbits of Saturn and Mars. He is so big that the matter of all the other planets could be easily packed inside him. In these pages we read many interesting things about this great planet with its curious belts and markings

THE Earth on which we live may seem a large place to us, but as a matter of fact it is very small, compared with some of the other planets, and if we could see it passing across the disc of its big brother Jupiter, the largest member of the Sun's family of worlds, it would seem little more than a dot.

The King of All the Planets

Jupiter is indeed a huge world. Whereas the Earth's diameter is just under 8,000 miles, Jupiter is 90,000 miles across at his equator, which is more than eleven times the Earth's equatorial diameter. But Jupiter is a much more flattened world than the Earth, and his polar diameter is only 84,200 miles or a sixteenth less than the diameter through the Equator.

It is when we think of the space that the great planet Jupiter occupies that we realise how very much bigger than the Earth he is. We could pack about 1,350 Earths inside Jupiter, which is larger than all the other planets of the solar system put together.

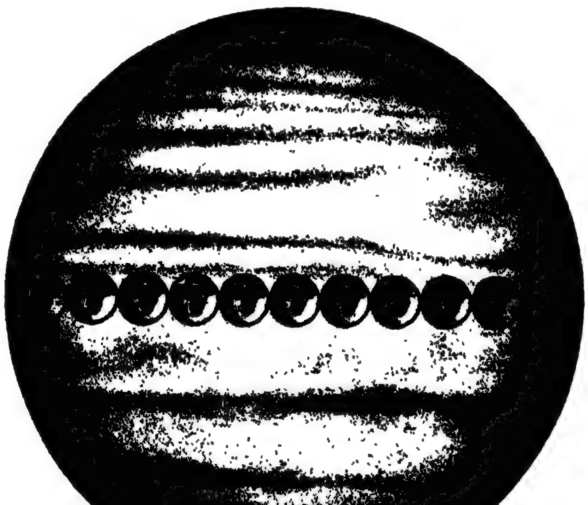
The circumference round the Equator is nearly 300,000 miles, so that a rope which would stretch from the Earth to the Moon would be altogether too short to go right round Jupiter. Indeed, we should want about 70,000 miles more of rope to complete the circuit. But although Jupiter is so much bigger than the Earth in size, the matter of which he is composed is much less dense than the Earth's, and so his weight or mass is equal to only 317 Earths.

Astronomers tell us that Jupiter is about one quarter as dense as the Earth, for while Jupiter is only a third heavier than a globe of similar size composed of water, the Earth is $5\frac{1}{2}$ times as heavy as a globe the size of the Earth would be if made of water.

Travelling at 30,000 Miles an Hour

Jupiter turns round on his axis just as the Earth does, but in very much less time, for he makes one complete turn in 9 hours 55 minutes, so that his day is not much more than a third of one of our days on the Earth. What an enormous speed this is for a great globe to whirl round at. If anyone could stand on the equator of Jupiter he would be rushing round at the rate of 30,000 miles an hour, and yet, of course, he would feel no more giddy than a person living in Singapore feels when he is whirling round with the Earth at the rate of rather more than 1,000 miles an hour.

Of course, the speed with which Jupiter turns round on his axis has been discovered by watching various marks on his surface, but the curious thing is that when the progress of the marks is observed at different times the period of rotation works out slightly differently. This is due to the fact that when we are looking at Jupiter we are not looking at a solid ball like the Earth, but at a mass of clouds.



The diameter of Jupiter is eleven and a half times that of the Earth. We see here in graphic form how very small the Earth is compared with its big brother

Whatever the great bulk of Jupiter may be, there is no doubt that his surface is completely covered with clouds, probably of carbon-dioxide gas. These vary in colour from time to time, and they appear in dark belts and lighter zones across the planet.

The belts vary in colour and width at different periods, and the markings that appear on them sometimes move together or away from one another at a rate of three or four hundred miles an hour. This movement among the clouds of Jupiter is believed to be due to mighty rushing winds, and if so the giant planet has storms compared with which the terrible tornadoes, which sweep over the surface of the Earth at 100 miles an hour, are little more than gentle breezes.

While the dark parts on Jupiter vary in width from time to time, they are sometimes as much as 10,000 miles wide. Sometimes bright spots appear on these, gradually turn red, and then disappear altogether.

The Mysterious Red Spot

The most remarkable feature that has ever been seen on Jupiter was a huge oval spot, first detected in 1857. In 1878, however, it became very prominent, assumed a pinkish colour which, as time went on, changed into a bright red so that it came to be known as the Great Red Spot.

It was indeed a great spot, the most conspicuous marking ever seen on any planet. At its greatest extent it was 30,000 miles long and 7,000 miles broad. Naturally astronomers watched it very closely, and wondered what it could be. As the years went on the Great Red Spot changed very much, then gradually it became fainter and fainter, till it practically disappeared, but in 1919 and again in 1927 it grew prominent once more.

There have been all sorts of theories as to what this strange feature could be. One idea was that it must be a gap in the clouds through which the more substantial part of the planet below could be seen. It seems difficult, however, to believe that such a huge gap should occur more or less in one place and remain a gap for so many years.

Another idea is that it is a kind of whirlwind in the cloud belt, but there are good arguments against this being a fact, for the Great Red Spot sometimes has pointed ends and this could not be if it were a whirlwind.

Jupiter's Long Year

So far no satisfactory explanation can be offered as to the nature of the spot, and the reason for its strange persistence.

Not only does Jupiter rotate on his axis like the Earth, though his axis is tilted much less than that of the Earth, but he also revolves round the

Sun in an orbit just as our world does. But it takes nearly twelve of our years for him to go round, or in other words a year on Jupiter is equal to eleven of our years and 315 days in addition.

Jupiter is about 483 million miles from the Sun, but as his orbit is an ellipse like that of the Earth he is sometimes nearer and sometimes farther away, according to his position in the orbit. The difference between his greatest distance and his least distance from the Sun is 42 million miles.

If we were standing on Jupiter we should see the Sun as a tiny disc in the sky only one-fifth of the Sun's diameter as it appears to us looking from the Earth Because of its great distance the solar light and heat on Jupiter are only one 27th as intense as they are on the Earth's surface.

A Brilliant Planet

Yet Jupiter as we look at him in the sky is a very bright planet. He stands next to Venus in the order of brilliance among heavenly bodies. He is brighter than Mars even when that planet is nearest to us, and he is five or six times as bright as the Dog Star, Sirius. The reason that he is so bright is that he is so big. What is lost in distance is made up in size, and so we have a very brilliant object in the night sky.

What sort of a body is Jupiter? Until quite recently it was supposed that the planet had a high temperature and was hot on his own account for the same reason that the Sun is hot, that is, because a process of condensation is going on. Jupiter was described as a sort of "semi sun," hot enough to be self-luminous.

One distinguished astronomer wrote, "It is safe to infer from the density and gravity pressure of Jupiter that its interior is very hot It has been supposed indeed by some that its surface is very hot and partly self-luminous; but such cannot be the case, for the shadows cast by the satellites on the planet are perfectly black, and when a satellite is in the shadow of Jupiter it is invisible.

Is the Great Planet Hot or Cold?

"No disturbances distinctly resembling volcanic activity have been observed, but Jupiter is so far away that they could not be seen unless they covered a region several hundreds of miles across.

"In conclusion we shall probably be near the truth if we suppose that Jupiter is not in an advanced stage of its evolution, like the terrestrial planets, but that it contains enormous volumes of gases which are in rapid circulation both along and perpendicular to its surface, and that the energy of its internal fires still gives rise to violent motions."

In recent years, however, astronomers have come to quite a different conclusion Sir James Jeans, the distinguished English astronomer, says, "Jupiter is almost unimaginably cold. The amount of heat we receive from it shows that its temperature must be about 270 degrees below zero on the Fahrenheit scale This is so cold that not only would water be frozen, but the commonest gases, like those of our own atmosphere, would be turned into liquids. Yet the planet is not altogether devoid of activity: definite features appear in its atmosphere which persist for a time and then disappear, much as

An actual photograph of the planet Jupiter, taken at Lowell Observatory in America in 1915. The Great Red Spot can be seen on the right

rain-clouds do in the atmosphere of the Earth. The clouds of Jupiter must presumably be clouds of carbon-dioxide or of some other gas which only condenses at very low temperatures."

Men of science have been able to measure the very small amount of heat which we receive on our Earth from the planet Jupiter, and it is found, contrary

A photograph of Jupiter taken by Mr. W. H. Wright in 1927. The spot in the lower half of the planet is one of the moons crossing the disc

to what was previously thought, that Jupiter's temperature is just about that which would be maintained by the Sun's heat alone at that enormous distance. Thus in a year or two we have had completely to revise our ideas about the condition of this biggest member of all the Sun's family.

A reference has been made to the satellites of Jupiter. There are, so far as is known, eight of these and four of them are so big that we can see them quite easily if we look through a field-glass or even a good opera-glass. In using the glass we should put our elbows on the window-ledge or some other firm support, so as to keep our hands with the glass steady.

It is rather interesting to remember that the four large moons of Jupiter were really the first heavenly bodies of whose discovery we have any record. Galileo found them when looking through his newly invented telescope in January, 1610. They were given the names of Io, Europa, Ganymede and Callisto

A World with Nine Moons

No more of Jupiter's moons were found for nearly three centuries, and then in 1892 Professor Barnard, at the Lick Observatory in America, discovered a fifth satellite. This is very small and can be seen only by means of the most powerful instruments. It is the nearest of all the moons to Jupiter, being only 112,500 miles from the centre of the planet Its diameter does not exceed 100 miles.

But this is not Jupiter's smallest moon. During the present century four other satellites have been found by means of photography, and the ninth is probably only about 15 mile in diameter, the eighth being very little larger. The four larger moons discovered by Galileo are enormous in comparison, their diameters ranging between 2,000 miles and 3,580 miles. Some of them are thus larger than the planet Mercury.

For some reason that is not known the fourth moon of Jupiter has a very dark complexion, and when it crosses the face of the planet it appears as a very black spot that can hardly be distinguished from its own shadow The other moons when they cross Jupiter's disc appear bright or dark according to the brightness at the time of that part of the planet.

Jupiter Aids a Great Discovery

The two outermost moons are a vast distance from their planet, revolving in orbits more than seven million miles from Jupiter, taking two years to complete one revolution. Perhaps their greatest marvel is that, compared with all the planets in their path round the Sun and the majority of satellites in their journeys round their planets, these two outermost moons of Jupiter are believed to revolve in the opposite direction.

The moons of Jupiter suffer eclipses just as our moon does, and it was by working out the exact times of the eclipses of Jupiter's satellites and comparing them with the times that we saw the eclipses from the Earth, that man first discovered within very little the speed at which light travels. Previously it was supposed that the speed of light was infinite, or in other words that in its travels it took no time at all to reach us or any other distant heavenly body.

THE GREAT MORTALITY IN ENGLAND

What would happen if half the people of the world were to be suddenly carried off by some great catastrophe, if half the population of Great Britain suddenly died, and every other country were in the same terrible plight? The confusion that would result is almost inconceivable. Yet a catastrophe of this magnitude has once overtaken the world, and, as we read, here in England it resulted in a drastic change in the whole scheme of life

In all the Great War about ten million fighters lost their lives throughout the world, and the deaths for Great Britain and Ireland alone were 812,317. Germany had over two millions killed, Russia nearly two millions, and France nearly a million and a half. But these deaths, terrible as the figures are, were not a huge proportion of the populations of the different countries.

During the years of the War the population of the world is estimated to have been 1,623 millions, so that less than one 200th of the population was killed. In Great Britain and Ireland, where the population was 46 millions, the proportion of killed was one out of every 57 persons. This was bad enough and led to startling changes in industry and other departments of life. But what would have been the result if, instead of one in 57, one out of every two persons in the country, men, women and children, had lost their lives?

This is the actual proportion of deaths in the great plague which overtook England and Europe and the whole known world in the middle of the fourteenth century. Nothing else like it is found in history, and although, strangely enough, many history books give very little attention to it, the Great Mortality or Black Death, as it is called, was a real turning point in the history of England, if not in the history of mankind.

A Succession of Disasters

Let us go back to the beginning. Somewhere about the year 1330 there began in China a series of terrible disasters which followed one another in quick succession for about seventeen years. These included drought, floods, ruined harvests, locusts, earthquakes and famine. Millions of people and animals died.

In one year alone, in the Southern Provinces, it is said that famine and flood caused the deaths of 13 million individuals. Millions of bodies lay about unburied, and it is hardly surprising that pestilence soon followed the other disasters. This pestilence seems to have been the well-known bubonic plague which has continued in Asia right down to our own time. Not many years ago, till the British stamped out the plague, this disease carried off millions every year in India.

The plague of the fourteenth century quickly spread from China along the great caravan routes to Constantinople and the harbours of Asia Minor, whence ships carried it to Cyprus, Sicily, Marseilles and Italy.

In those days sanitation in both East and West was conspicuous by its absence, and it is not surprising that having once gained a footing in Europe the plague should spread rapidly to all countries, taking its toll of lives as it travelled. It spared none; rich and poor, old and young, strong and weak, all fell victims to the cruel scythe that mowed down right and left. In Germany, where a million and a quarter people are said to have died, no fewer than 124,000 Franciscan friars fell victims to the terrible disease. In Paris 50,000 people died, and while the plague raged Cairo lost from between 10,000 to 15,000 people daily. A modern historian believes that Europe alone lost by the plague of those terrible years 25 million inhabitants. Never was there such a scourge.

Ships with their crews all dead were seen tossing on the seas

In some districts the plague brought sorrow and mourning, while in others the people with a kind of hysteria indulged more than ever in frivolity and mirth.

It was not to be expected that, with the plague sweeping across the world, England should escape, and sure enough, in August, 1348, a ship arriving at Melcombe Regis, now a part of Weymouth, and then a trade centre of considerable importance, brought germs of the plague and started the Great Mortality in England.

Rumours of what was happening on the Continent of Europe had reached England earlier in the summer, but in those days people paid more attention to charms and prayers than to sanitation and hygiene. Prayer is good in its place, but it is no substitute for sanitation in resisting contagious and infectious disease.

Prayers Against the Plague

The aid of the priest rather than that of the doctor was sought in health matters, and the only precaution against the entry of the plague into England seems to have been an order by the Bishop of Bath and Wells for processions every Friday in the churches to beg God to protect people from the pestilence which had come from the East. The Bishop also urged the people to give alms and to fast and pray in order, if possible, to avert the Divine anger. Such religious exercises were no doubt good, but they should have been accompanied by quarantine regulations and orders for a more sanitary and hygienic way of life.

Having obtained a foothold the plague soon spread. It swept over the southern districts, destroying numberless people in Dorset, Devon and Somerset. People who were well in the morning were dead by midday, and there was no respect of persons. Fear seized all. Even the eyes of people were considered as sources of contagion which had the power of acting at a distance.

The ordinary course of daily life soon began to be upset. Some villages

were left entirely without inhabitants. Priests and monks and friars were struck down like ordinary people, and in those days, when religion played such a large part in the lives of the people, the absence of priests to minister to the sick and dying was regarded as a terrible calamity.

Onward marched the angel of death, till at last he reached Westminster and London in November, and here he had a fruitful field for his operations. London, with its narrow streets and overhanging houses shutting out the sunlight, with its cesspools, and garbage heaps, with its butchers slaughtering the animals in the streets and allowing their blood and offal to lie about or run down the ordinary gutters, with its unventilated houses, had no chance against an infectious disease of this kind.

We do not know exactly what the population of the capital was at that time, but at least half of its people were carried off by the plague in a few weeks.

Edward the Third, fresh from his triumphs on the Continent, the greatest conqueror of his day, to whom the Imperial crown of Germany had been offered, was no match for an enemy of this kind. Away went the plague like the wind to the north, and wherever it went it cut down men, women and children of all classes and ages. Life became dislocated. In many districts there were no people to plough and sow and reap and attend to the cattle.

No Men to Till the Land

Lord Russell has asked us to consider what would happen if a plague swept over the world to-day killing only one per cent. of the people, but that one per cent. the technical experts on whom we are so dependent. If this happened we should have no light or heat; our factories would have to stop; our transport would be brought to a standstill, and life would revert to what it was in primitive times.

Something of this kind happened in the days of the Great Mortality or Black Death. There were no technical experts in the scientific sense then, but the labourers were the people who understood agriculture, and when half of them were swept off it was difficult to find men with the knowledge and ability to till the land and attend to the cattle and produce the necessary food for the nation.

Nothing could keep the plague out. When the men of Gloucester tried to do so by cutting off all intercourse with Bristol, they soon found that the plague had beaten them, and they died as did others, passing on the plague to Oxford which, in turn, passed it on to London.

Ordinary burial was impossible, and hundreds, and in some cases thousands, of bodies were interred together in great pits. A contemporary record tells us that in one pit in London alone 50,000 bodies were buried; but this, of course, must be an exaggeration.

So completely did terror kill all kindlier feeling that neighbour fled from neighbour, brother forsook brother, sister left sister, and wife and husband fled from one another, even children being forsaken by their parents.

Ships Without Crews

No place was immune from the dread disease. It swept over sea as well as over land, and many ships lost the whole of their crews, with the result that vessels were seen tossing about on the Mediterranean and in the North Sea with no living soul on board. All had fallen victims to the Black Death, so called because of a darkening of the skin which resulted.

It is difficult to imagine anything more dramatic than these ships tossing on the waves like the mythical Flying Dutchman, with no crews to guide them into port. No wonder commerce and social intercourse came more or less to a standstill, and every man suspected his brother for fear he should be a messenger of death.

In London and other cities no attempts at dealing with the plague in a sanitary way seem to have been made. The narrow dark streets, with the blood of slain beasts running down them, still remained uncleansed. The houses remained unventilated, the yards undrained. The offal from the butchers' cattle was still thrown into the Thames, and as we think of this terrible state of affairs, we can understand that the plague, so far from being banished, found an ideal place of abode.

As the plague stalked through the land it did not spare monasteries, even in isolated districts. Any caller might bring the plague, and in some monasteries all but one or two of the monks died. When newcomers took their places they also were smitten down by the plague. The parish priests were in the same plight, and the records show in some parishes a succession of priests, each smitten down within a few months.

Land went out of cultivation, buildings went into ruin, all because there was no one to attend to them. In the Bedfordshire records we read of a cloth mill on the Manor of Storington, which stood idle and worthless because, as the old document says, "it stands empty through the mortality of the plague and there is no one who wishes to use it or rent it for the same reason."

In those far off days people little realised the danger of contact with infectious disease. The Scots, hearing of the cruel pestilence among the English, thought this had happened to them as a judgment at the hand of God. They, therefore laughed at their enemies, and thinking that while the plague had overwhelmed the English it would not touch them, they assembled an army in the forest of Selkirk with the intention of invading England. Contact brought infection, and the Great Mortality came upon the Scots like an avalanche, so that in a short time about 5,000 of their army died.

Silence Settles Over the Land

A strange silence settled over England, for many a water mill whose sound had been heard in the countryside ceased to work because there was no one to occupy it or attend to it. It would be bad enough now for a country like England to lose half its population suddenly, but with modern machinery those who remained could soon produce what was needed for the survivors. In the fourteenth century, however, when the population of England and Wales was probably less than five millions, it was a very serious thing indeed for two millions and a half to be carried off suddenly.

The period just before the Black Death had been a prosperous one for England. Her king was victorious, the spoils of war had come to her, and the prosperity was shown by the building of magnificent cathedrals and churches all over the country. But now with

Land went out of cultivation and mills became ruins

the pestilence came a cessation of the building.

At Great Yarmouth, a splendid pair of western towers was being erected for the great church of St. Nicholas. The builders were carried off by death, and the work stopped, never to be resumed. This was only one of many such instances. The manufacture of beautiful coloured glass was in the same plight. It had reached a great height of perfection, and then came the Black Death, sweeping away the skilled workmen, and we find a break in the progress of this art. In fact, as a distinguished historian has said, the steady progress of the twelfth and thirteenth centuries was suddenly checked in the fourteenth.

The Black Death had swept off half the population, and the whole social structure was disorganised. Existing institutions were simply shattered, and the historian writes: "Many a noble aspiration which, could it have been realised, and many a wise conception which, could it have attained its true development, would have been most fruitful of good to humanity, was stricken beyond recovery . . . Two of the noblest churches in Italy typify the two-fold aspect of this great visitation, the Cathedral of Sienna and the Cathedral of Milan.

Great Works Stopped

"The former is but a fragment of what was originally conceived. It was actually in course of erection and would have been not less in size than the present St. Peter's had it been completed. The transepts were already raised and the foundations had been laid, when the plague fell upon the city. The works were necessarily suspended, and from that day to this have never been resumed."

One curious result of the plague was that a smaller proportion of Jews was attacked than of Gentiles. This was probably due to their more sanitary way of life owing to their observance of the hygienic rules of the Law of Moses. But whatever was the cause, the result roused the hostility of other peoples, who began to accuse the Jews of poisoning the wells and even the atmosphere. At once persecution broke out, and thousands of them were put to death.

Under torture, of course, many confessed that they were actually guilty of the crime imputed to them. This did not occur, however, in England. In Basle the people obliged their Burgomaster and Senators to bind themselves by an oath to burn the Jews and to forbid people of that community from entering the city for a space of 200 years. All Jews were thereupon destroyed without trial, and similar scenes took place in other towns. The Jews were said to obtain the poison they used from spiders, owls, and various venomous animals.

Another result of the Black Death was the rise of a curious religious body called the Flagellants, people who went about in bodies whipping one another, believing that thereby they were appeasing the Deity and helping to allay the plague.

Changes in Cultivation

But the greatest result that came from the Black Death in England was a complete change in the old methods of cultivating the land. Up to this time the landowners had it all their own way, but now with at least half the labourers and many of the old tenants swept away, the landowners were in difficulties. Rents fell to half their former value, and still there were no tenants. Thousands of acres went out of cultivation. Cottages, mills, orchards and fields went to waste, and as a result there was a great rise in the price of food and other commodities.

The workers bargained with the landowners for higher wages

In many cases the rise was 200 per cent. Herrings, which at that time formed a considerable part of the food of the people, became dear and beyond the reach of all but the rich, and so great was the shortage of fish owing to lack of fishermen that people were obliged to eat meat on Fast Days.

High Wages Follow the Pestilence

The labourers were quick to seize their opportunity, and when they asked for high wages, although a statute was passed prohibiting this, many landowners were only too glad to pay the high wages in order to get the help they needed. Men's wages rose fifty per cent. and women's a hundred per cent.

When the landowners pleaded the high wages they had to pay as an excuse for not finding the money to meet the royal taxes, the King gave orders that those who asked and those who paid higher wages than had been prescribed by law should be imprisoned. But this was a foolish policy, for districts where the workers were imprisoned soon became famine-stricken as there was no one then to do the work and grow the food.

More than a third of the land throughout the entire kingdom remained uncultivated, and the labourers and skilled workmen, banding themselves together, became so rebellious that nothing could be done to punish them. The King's statute refers to this demand of the workers for high wages as "the malice of servants in husbandry."

The old system of landowners farming their own land by bailiffs was discontinued, and land was let out to those who, at a fixed rent, would undertake to work it. It was in these days that we find the beginning of trade unions, for there were alliances among workers to keep up their wages.

The Power of the People

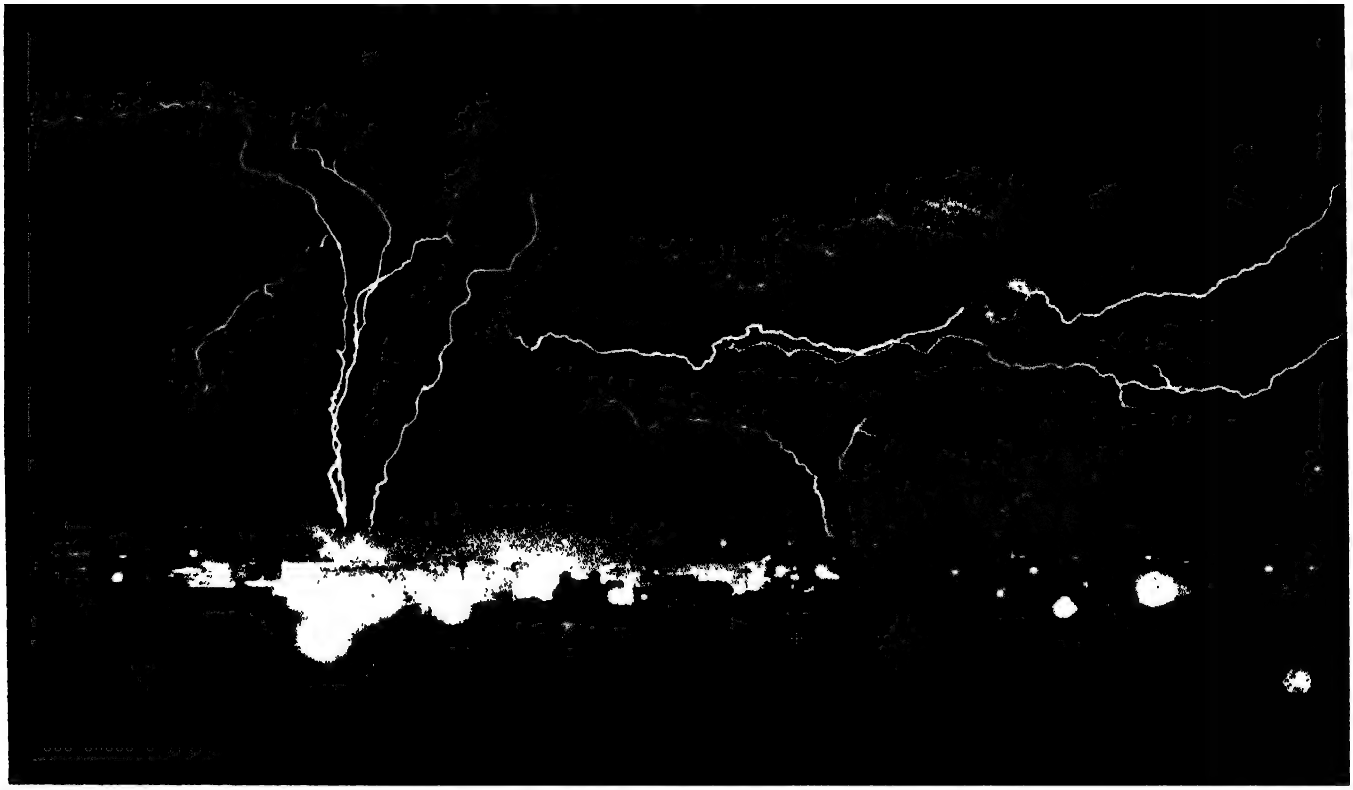
The Great Plague had done one thing for England: it had taught the common people their own power, and although for the next thirty years lords and landowners strove fiercely to prevent the overthrow of the old system of serfdom, the people were masters of the situation and eventually won the day.

Another change brought about by the Black Death was the dividing up of the land by hedges, so that individual tenants could farm their own land instead of having large fields in common. This division of the fields by hedges has remained a distinguishing feature of the English landscape ever since.

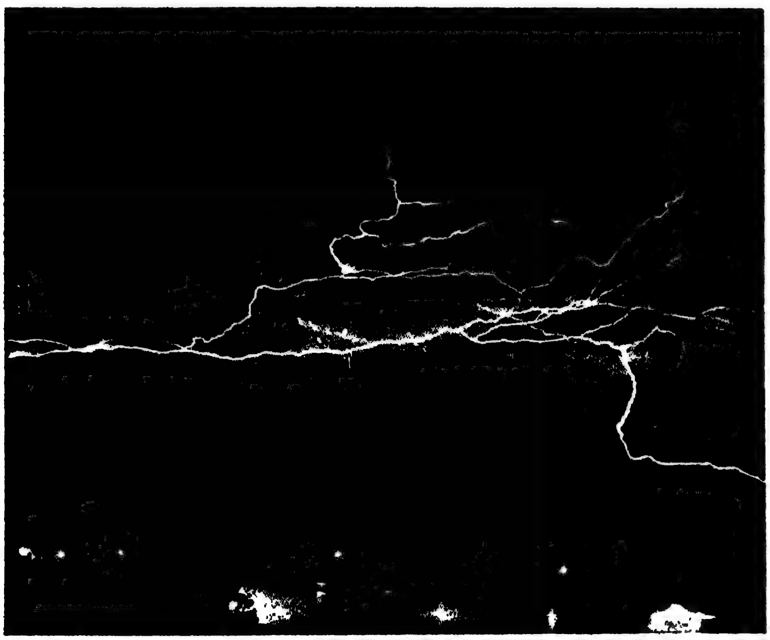
Still another result was, that the poor people became far richer than they had hitherto been, for as the population was halved and the amount of money in the country remained the same the money possessed by the survivors was doubled. Small freeholders who worked their land by the labour of themselves and their families were able to buy land very cheaply from the lords and landowners who could no longer afford to work it with hired labour at the new high wages. Many a landowner found himself faced with ruin and so was compelled to sell his land.

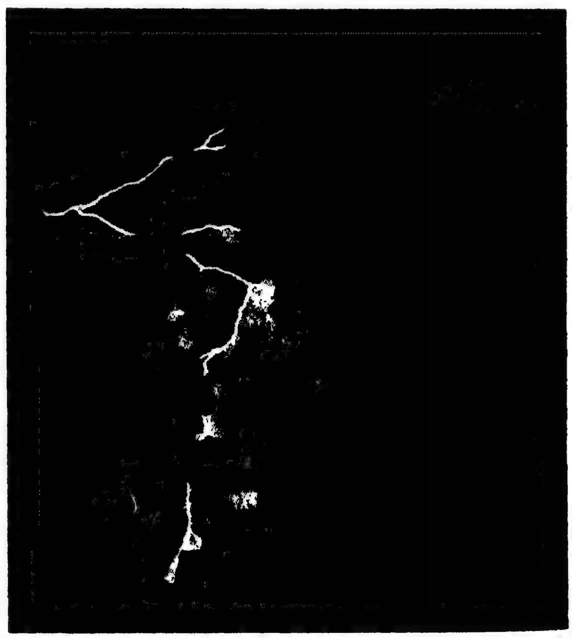
We know how the Great War transformed the old conditions, but the changes that we have seen since 1914 are as nothing compared with the changes which England saw after the Great Mortality of 1348 and 1349. It marks an epoch in our history.

LIGHTNING WITH MORE ENERGY THAN NIAGARA



Thunderstorms with flashing lightning occur in all parts of the world. Scientists tell us that there are as many as sixteen million thunderstorms every year, or 44,000 a day About a hundred flashes of lightning are seen somewhere in the world every second of time. As can be seen in this remarkable photograph, the flashes move in wavy lines as the current passes between highly charged clouds, or between clouds and the Earth. The old-fashioned way of drawing lightning as a series of straight lines and angles was incorrect, as modern instantaneous photography has proved. The lightning flash meanders rather than zigzags. The lightning, although sometimes it does harm, also does much useful work, for it produces every year about 100,000,000 tons of nitrogen compounds from the air, which fertilise the soil and make it produce more food than it would otherwise do





The photograph on the left shows a wonderful series of lightning flashes, five miles long, that were witnessed over Baltimore Harbour, and the photograph on the right was taken at Toronto in Canada. Buildings are protected by lightning conductors, which, by means of a metal channel, guide the flash, if it should touch the building, into the ground. Lightning is exceedingly erratic, and many cases are on record of its puzzling manifestations. A boy holding a hymn-book from which he was singing had the book torn out of his hands and destroyed, but he himself was not injured. The same thing happened to a man with a whip. Two ladies knitting had the knitting needles torn from their hands, but the ladies were not hurt. A man was carrying a pitchfork over his shoulder when the fork was struck by lightning, the prongs twisted into corkscrews, and the whole thing thrown fifty yards away. The peasant was not injured. Far more energy is generated by the lightning flashes of one hour than is produced by Niagara Falls in the same time

WONDERS of LAND & WATER

THE WONDER OF THUNDER & LIGHTNING

There is no more awe-inspiring phenomenon in all Nature than a thunderstorm. The crashing, rumbling sound of the thunder re-echoed by clouds and Earth is often terrifying to those who do not know the cause. The sounds are really due to the crack of the electric spark as electricity flashes from one electrified cloud to another, or from a cloud to the Earth. The energy of the lightning is enormous, and here we read something about the marvels of the thunderstorm

Although in England we do not get many thunderstorms, men of science tell us that every hour there is an average of 1,800 thunderstorms going on somewhere in the world, and these give 360,000 lightning flashes or 6,000 a minute.

There is always, of course, danger from lightning, but why more damage is not done than actually occurs is due to the fact that so few flashes hit a terrestrial target.

The clouds that float above our heads are nearly always more or less charged with electricity. As the minute particles of the water-vapour making up these clouds unite to form larger particles, the strength of their electric charges increases. Eight small drops, for example, when they unite, will form a drop that is only twice the radius of the small drops, but has eight times the electric charge. Thus, a mass of cloud in which the tiny particles are uniting, becomes electrified more and more, and when it comes near another cloud charged with electricity of the opposite kind, there is a discharge with a flash which we know as lightning.

Sometimes the lightning passes between cloud and cloud and sometimes between a cloud and the Earth. After the flash there is a loud sound or succession of sounds sometimes rumbling for a minute or more. This sound is produced in the following way: The electric flash heats the air in its path, and does this so rapidly that there is a sudden expansion producing a partial vacuum. At once the air from all round rushes in to fill up the vacuum and it is the sound of this rush which we hear and call thunder.

When the path of the flash is short and straight one light clap is heard, but if the path of the lightning be a sinuous one and passes over a considerable distance, we hear a succession of sounds one after the other, and further, the echoes among the clouds come rolling down to our ears.

The speed of light is 186,000 miles per second, so that we see the flash of lightning practically at the same instant that it was produced. Sound, however, travels in air at only about 1,100 feet per second, or one mile in five seconds. The result is that the sound of the rushing air reaches us from the different points along the line of flash at different times, and so we hear the sound as a succession of claps and rumblings.

It is interesting after we have seen the flash to count the seconds till we hear the first clap of thunder. We can then estimate how far away the lightning was. We can also tell by noting whether the interval between the flash and the report gets shorter or longer as the time goes on, if the storm is approaching or receding from us.

This tree was shattered by lightning. It practically exploded, the energy of the lightning being transformed into heat and suddenly turning the sap and other fluids in the tree trunk into gas, so that the tree burst

Some people have an idea that the impression we get of a very long flash is only an optical illusion, but scientific experts who have studied the matter tell us that the lightning flashes are really as long as they look. Often a flash is five miles in length. An average flash of lightning has enormous energy and is equal to the driving power of a 200-ton train travelling at a speed of 50 miles an hour.

The total energy represented by the 360,000 lightning flashes which occur somewhere in the world every hour is more than a million and a half horse-power operating continuously. This is more than the horse-power produced by the power stations at Niagara Falls.

It has been concluded that to produce a flash of lightning a mile in length would require over 3½ million electric cells.

There are three kinds of lightning, one of them, known as ball or globe lightning, being rare, and rather mysterious in its action. The flashes which we see travel during a severe thunderstorm are known as forked or zig-zag lightning. This kind of lightning appears to our eyes to turn at sharp angles and the old artists used to draw it so, but instantaneous photography has shown us that the lightning-flash really travels as a sinuous line, something like the course of a river with its tributaries at various points.

A third kind of lightning is known as sheet or summer lightning. We hear no thunder, but see the sky lighted up as though a giant flash-lamp were shone on to the clouds. This is actually not another form of lightning. It is the reflection on the clouds of flashes of forked lightning in a distant storm. The storm may be as much as fifty miles away.

It is a good thing for us that only about one flash in a hundred ever reaches the Earth, and most of those that do come to earth are conducted harmlessly into the ground by means of lightning conductors or trees. It is a fact that most of the tall buildings, including the Eiffel Tower, have been struck by lightning a number of times, but their conducting rods have taken the current safely to earth without damage to the building. We read something about lightning conductors in another part of this book.

The popular idea that lightning never strikes twice in the same place is quite wrong. It often strikes the same spot two or even more times. Of course, to stand under a tree during a thunderstorm is very dangerous, and

many people and animals have been killed by the lightning conducted to them down the tree. But it is also dangerous to stand up or walk across a field or open space during a thunderstorm, especially if one is carrying a metal implement such as a golf club, a spade, a rake, or even an umbrella with a metal rod or metal ferrule.

To render oneself safe it is really necessary to sprawl flat on the ground, having put down the metal implement 300 feet or more away. A good scheme during a thunderstorm, if one is caught out, is to sit under a thick bush or a hedge at least a hundred yards from any tree.

It is a curious thing that there is no instance on record of a train being damaged by lightning Ships have been struck, but that is very rare.

It is foolish to be unduly alarmed, but at the same time we should take wise precautions. For instance, there is no need to be nervous because knives and forks are lying on the table, nor because we are wearing eyeglasses with metal rims. Professor Lowe has said that lightning would be attracted to knives and forks on the table to approximately the same extent that a bluebottle fly shakes a house with its feet.

On the other hand, there are people who think that rubber heels and soles on the shoes and rubber tyres on the wheels of the motor car are a precaution against lightning. "It would be easier," says Professor Lowe, "to put out the kitchen fire with a hundredth part of a drop of water, than to get protection in such a way. Lightning travels so fast and so powerfully that it would soon overcome such slight resistance."

Lightning plays all sorts of freaks. When it strikes men and women it sometimes strips them of their clothes.

A powerful flash of lightning wrecking the atoms of air, so that they lose some of their electrons

Early in the present century three women were standing round a reaping machine in France when one of them was struck by lightning and killed; the other two were injured and both had every shred of clothing torn from them, even their boots.

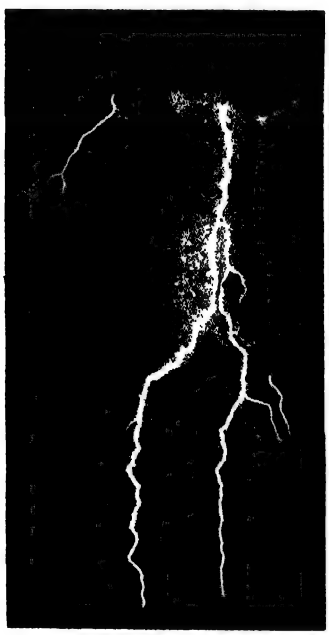
During a thunderstorm in Wales, a lightning flash passed down the chimney of a house and, without doing any damage to the building or its contents, lighted a fire laid in a grate the previous night. When lightning struck a house in Cheshire a scrubbing brush on a table had all the bristles torn out of it.

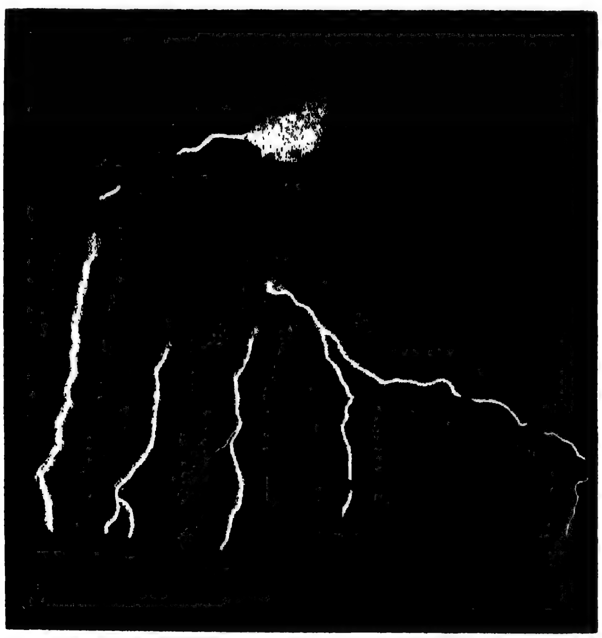
No one can account for the queer behaviour of lightning. Forty sheep were standing under a tree during a storm when the lightning struck the tree and killed twenty of the sheep. But these were not twenty that were standing close together; they were scattered among the total number.

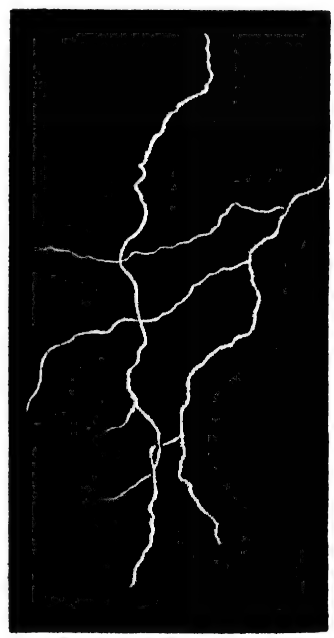
The lightning in passing from cloud to cloud or from cloud to earth takes the line of least resistance, and the wavy path and the flash itself are probably due to the presence of obstacles such as solid particles suspended in the air.

The popular idea that certain trees are immune from damage by lightning is not borne out by the facts. The Romans used to think that the bay tree was never struck, and the fig tree, the mulberry and the beech tree have all been reputed as "safe." But all of these trees have been struck and damaged by lightning. To-day it is believed by many people that the beech tree is never struck, but there are plenty of records of these trees being destroyed, their trunks split, and their branches torn away by lightning.

Monsieur Camille Flammarion, the famous French scientist, collected over a number of years, instances of trees







Here are three remarkable examples of lightning flashes passing from highly charged clouds to the earth. The voltage of a lightning flash often exceeds 100,000,000, so that its power is enormous. Buildings, particularly high ones, are often struck by lightning, but no harm is done if lightning conductors are fitted. Lightning conductors are thin copper rods reaching from the top of the building to the ground. The pointed top of the conductor attracts the lightning which is then carried by the rest of the rod to the ground, where it is harmlessly dissipated. The popular idea that lightning never strikes twice in the same place is quite a mistake

being struck, and he gives these figures: 54 oaks, 24 poplars, 14 elms, 11 walnut trees, 10 firs, 7 willows, 6 pine trees, 6 ash trees, 6 beeches, 4 pear trees, 4 cherry trees, 4 chestnut trees, 3 cantelupes, 2 lime trees, 2 apple trees, and 1 each of the mountain ash, mulberry, alder, laburnum, acacia, pseudo-acacia, fig tree, orange and olive.

The height of a particular tree, of course, accounts largely for its selection by the lightning, though it is not invariably the tallest tree in a particular group or field that is struck when the lightning flash reaches the Earth. Trees often explode with a loud report when struck by lightning and this is due to the fact that all the moisture and sap in them is suddenly vaporised and the expansion of the liquid as it turns to gas bursts the tree.

Globe lightning, which is very little understood, is described in another part of this book.

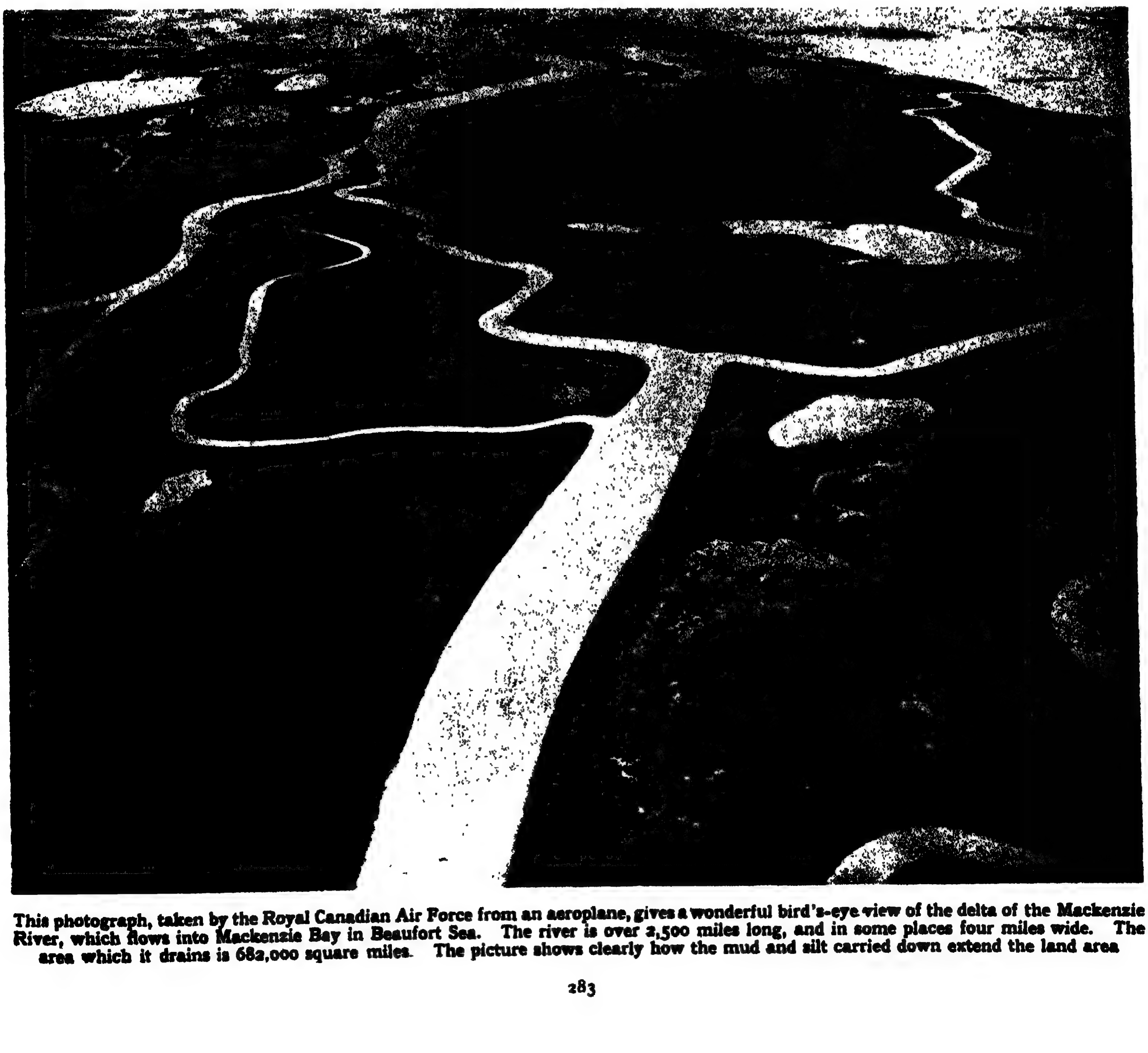
WHAT A DELTA LOOKS LIKE FROM THE AIR

All rivers carry to the sea a large amount of sediment which they have worn from their beds, and unless there is a strong tide this sediment accumulates. In course of time a number of low islands are formed on which vegetation begins to grow, and this vegetation helps to raise the level of the islands still more by forming quantities of vegetable mould.

Naturally the islands split the river's mouth into a number of branches. Such a formation at the mouth of a river is called a delta. This is the name of the fourth letter in the Greek alphabet, which consists of a triangle, and the name was first given to the Delta of the Nile which is actually in the shape of a triangle.

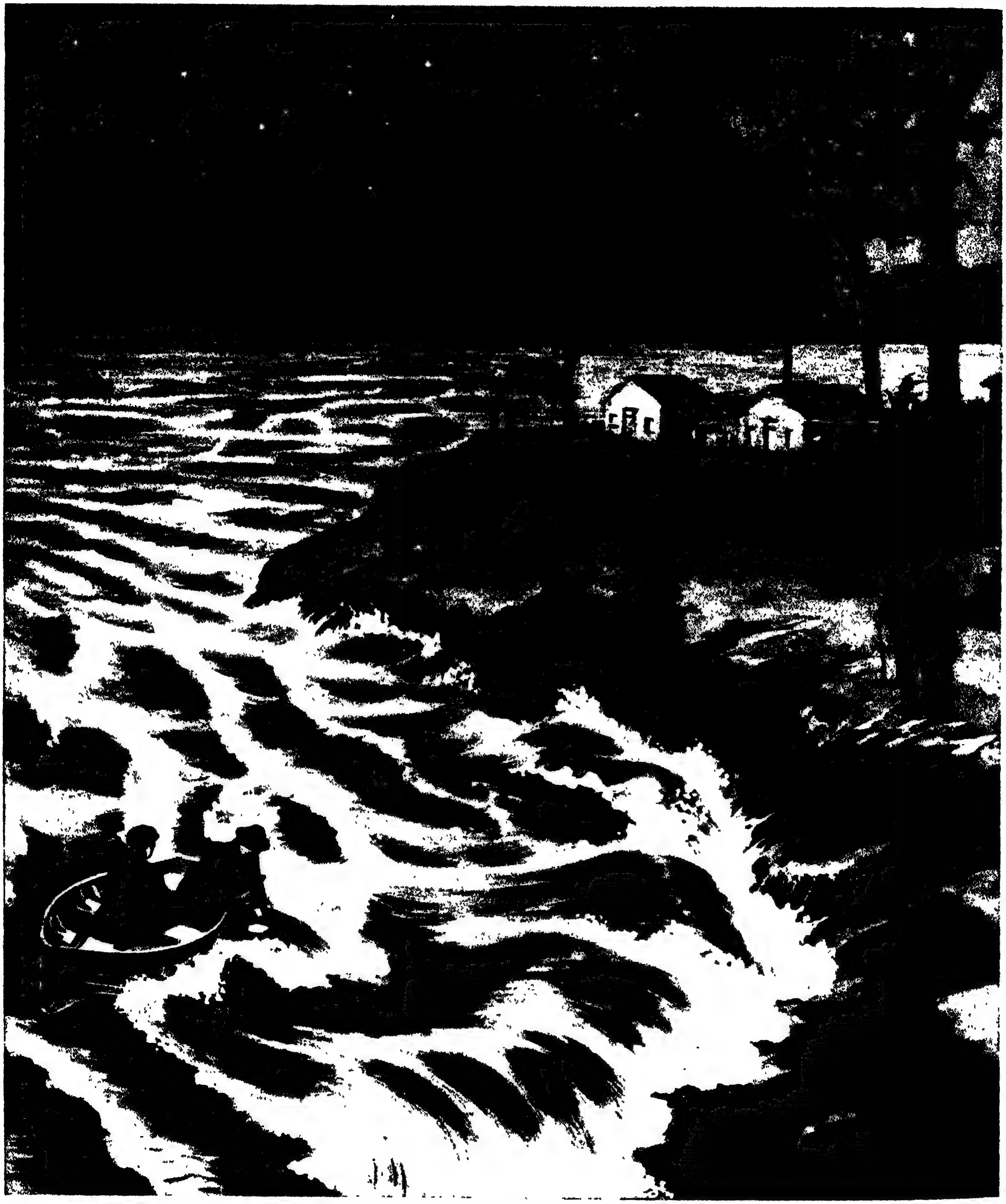
In the Delta of the Nile as well as in those in some other rivers, the flat plains at the mouth are traversed by a large number of tortuous channels, and the effect is to reduce the current of the river which moves fairly fast before it reaches the delta. As the rate of flow becomes less, more and more sediment is deposited, and the tendency is for the delta to become larger and reach farther out into the sea

The Mississippi River brings down such a vast amount of sediment that it has pushed tons of land far out into the Gulf of Mexico This delta grows out to sea at the rate of 250 feet a year. It covers something like 40,000 square miles, while that of the Ganges and Brahmaputra in India is as large as the whole of England and Wales.



This photograph, taken by the Royal Canadian Air Force from an aeroplane, gives a wonderful bird's-eye view of the delta of the Mackenzie River, which flows into Mackenzie Bay in Beaufort Sea. The river is over 2,500 miles long, and in some places four miles wide. The area which it drains is 682,000 square miles. The picture shows clearly how the mud and silt carried down extend the land area

A SEA GLOWING WITH LIVING NIGHT-LIGHTS



Fireflies and glow-worms are not the only creatures that give off phosphorescent light. There are still more lowly animals in the sea that have the same power, and among them are certain infusorians or protozoa, creatures of the simplest type, consisting of a single cell. They are known as the Noctiluca or "night-lights" and their size is about that of a pin's head. In shape they are almost a complete globe, and they have a whip-like attachment which enables them to move about by lashing it. These remarkable creatures are the most brilliant of all marine light bearers, and sometimes they appear in such numbers that the whole sea looks like a mass of liquid flame. This picture shows such an appearance seen in the roadstead of Simonstown at the Cape of Good Hope some years ago.

When these "night-lights" were gathered up in a bucket and carried inside a house the little creatures lighted up the room

DRIVING AN ENGINE WITH COAL GAS

It is difficult to say who really invented the gas engine, that is, the engine driven by coal gas. As is explained on this page, the gas engine is an internal combustion engine, its power being derived from an explosion that takes place in the cylinder behind the piston which is thereby driven forward. A scientist has very aptly called this "putting the furnace into the cylinder." A gas engine needs a heavy flywheel

PERHAPS we may say that the gas engine had its real beginning about 1680, when a French scientist and a Dutch mathematician both suggested that an engine might be made to work by power derived by exploding gunpowder. Nothing, however, seems to have been done, but a century later an Englishman, John Barber, took out a patent for what he called an "exploder." It was an engine in which the motive power was to be developed by exploding a mixture of gas and air. But nothing came of the idea at the time, although it is fair to say that this was the first actual suggestion of a gas engine of which there is any definite record.

Wasted Energy

Not until 1860, however, were gas engines made, and they were designed by a French engineer, Etienne Lenoir. Hundreds of them were made and used both in France and in England, but they were very wasteful, for they burnt a great deal of gas, and they were not very efficient.

As we know, coal gas and air make a mixture which will explode if a light be put to it. The principle of the early gas engine was that the explosive mixture should be drawn into the cylinder and then fired, whereupon the mixed gases would expand and drive forward the piston. The idea was carried out, but the difficulty was that the explosion took place so rapidly that the comparatively slow-moving piston could not keep up with the expanding gases, and so a great part of the energy of the explosion was conducted away as heat.

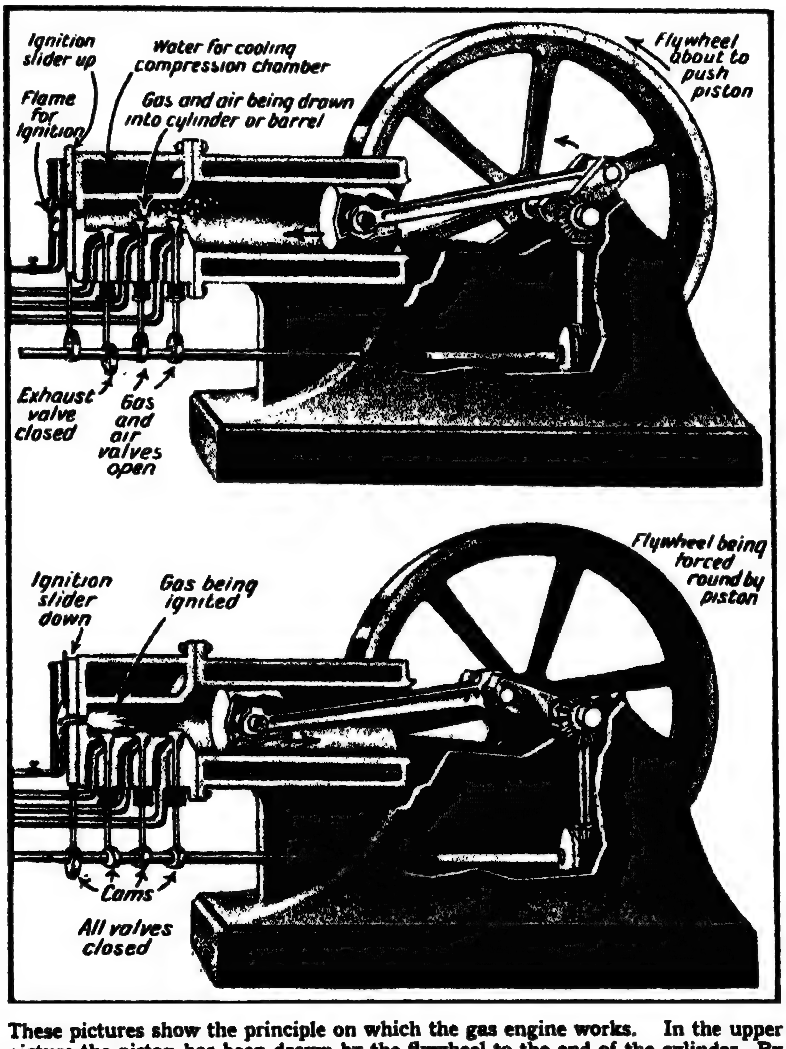
A great step forward was made when another French engineer suggested that the mixture of coal gas and air should be compressed before it was exploded in the cylinder. This was tried and proved successful, for by compressing the mixed gases the rapidity of the explosion was greatly decreased and the efficiency of the engine correspondingly increased. Other improvements rapidly followed, and in the last quarter of the nineteenth century the gas engine had taken its place as one of the great power-producing devices of industry.

The principle on which it works is quite simple, and is shown in the drawings on this page.

The cylinder is prevented from getting too hot by a surrounding jacket of cold water. Gas engines of this type can be worked with gas obtained from the ordinary town supply, but in many cases large works produce their own gas, in what is known as a producer plant, and thus gas engines can be used in country districts where there is no regular supply from a gas company.

Great Loss of Power

Of course, no engine, whether it be gas, steam or petrol, gives out as much power as is put into it. For instance, in an economical engine using crude oil, which was regarded as fairly efficient, only 31 per cent. of the whole energy was found to be available for use, the remaining 69 per cent. being wasted. Some of this waste in engines is due to friction of the moving parts, other waste is due to a great deal of heat being carried away by the exhaust gases, and other waste by heat absorbed in the cooling water.



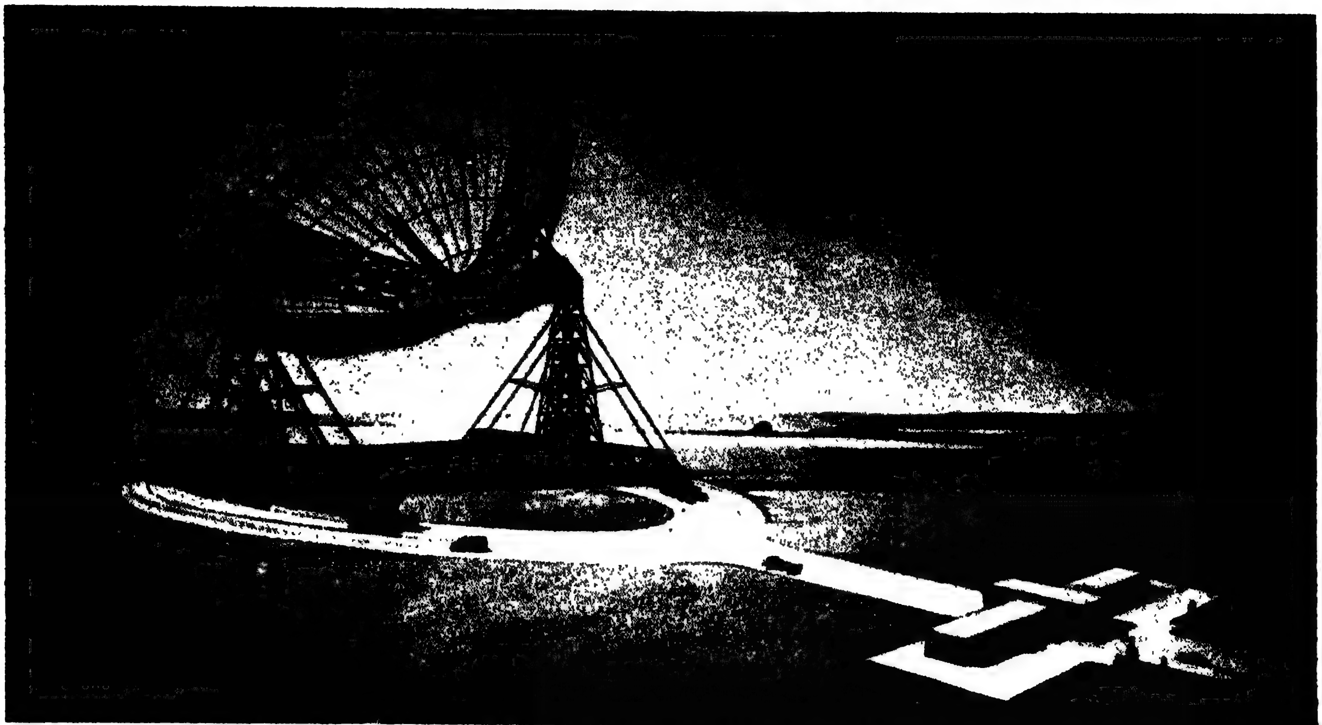
These pictures show the principle on which the gas engine works. In the upper picture the piston has been drawn by the flywheel to the end of the cylinder. By gear wheels and cams on a shaft two valves have been opened, admitting gas and air into the cylinder. The flywheel then drives the piston forward, compressing this mixture of gas. Then the flywheel begins to draw the piston back again, at the same time moving an ignition slider and admitting flame to fire the gas. The explosion drives the piston back, as shown in the lower picture, working the crank and giving the flywheel fresh power to continue rotating. When the piston once more comes forward it opens an exhaust valve and drives out the burnt gases. Then the flywheel draws it backward once more and the whole operation is repeated. The piston thus goes forward twice and backward twice for each explosion that takes place in the cylinder

AN EASY WAY OF FELLING A TREE

Here is the latest way of felling a tree. First of all a hole is dug with a hand trowel under the roots of the tree which are nearest to the surface, and these are then sawn through with a jointed saw, as shown in the photograph. When this has been done to the principal roots, the tree is ready for felling with a special jack, as in the lower picture

Here the tree, whose roots have already been cut through by the jointed saw, is being pushed over with very little trouble by means of the special jack designed for work of this kind. The jack is propped against a stone, as shown in the picture, the other end being wedged against the tree trunk. The handle of the jack is then worked to and fro, so as to push up the front part of the jack a ratchet at a time. After the jack has been worked up a few ratchets, the tree begins to come out of the ground, and in a minute or two the trunk has fallen. Such a method of felling a tree results in a great saving of expense over the older method of sawing and digging the tree out

LISTENING-IN TO INVISIBLE STARS



This drawing shows the 1,300-ton radio telescope used by astronomers of Manchester University to listen-in to the stars. On the left is the aerial · the buildings on the right house the receiving and recording instruments.

On page 41 it is stated that there are 7,647 stars visible to the naked eye and that nearly 2,000 millions more have been photographed through telescopes. In addition there are millions more known to exist but which are so distant or faint that they cannot be detected by the most powerful telescopes or the most sensitive of photographic plates With a radio telescope, however, astronomers are able to study stars they cannot see.

The elementary particles of which all matter, including the stars, is made up are in a state of constant movement, and as a result of these movements the particles emit radiation, in much the same way that a broadcasting station transmits a musical programme. But the signal strength of radiation from atomic particles is very low compared with that from a broadcasting station. Nevertheless, for some years sensitive receivers had been picking up radiations which were known not to have originated on the earth and, therefore, must be coming from outer space.

In 1948 observers in Cambridge, England, and in Sydney, Australia, found that some at least of the radio waves from space were coming from apparently fixed sources, and it was decided that these fixed sources must be stars transmitting their energy. They were therefore called radio stars, and many have now been discovered and their position established.

Astronomers now believe that radio stars must be dark objects which for some reason do not emit light but instead transmit intense radio waves. Radio stars are known to be present in large numbers in the nebulae that lie outside the Milky Way system, and it is believed that there are considerable numbers in the Milky Way itself.

There are two ways of using radio to collect astronomical data. One is by transmitting powerful radar signals and receiving them back as echoes from objects they strike in space. This method is limited to comparatively close stellar distances and has so far been used successfully only in the instances of the moon and of meteors.

Consequently, for radio examination of the stellar system astronomers have to be content with receiving transmissions from the stars themselves, and for that purpose the radio telescope was devised. The radiation is collected or received by what is called a directive or beamed aerial system. The aerial consists of a mesh cone with its open end pointing to the sky and is so mounted that it can be pointed in various directions. The movement of the aerial is governed by a clockwork or motor drive which counteracts the earth rotation and ensures that, while the aerial is directed to any point in space, observation is not distorted by the earth's own movement.

From the aerial, the radiations pass to a sensitive receiving set, very like a television receiver. The receiver is so sensitive that it can detect radiations from an object at a temperature only a few degrees above absolute zero. The received signals are then amplified and through electronic equipment operate a pen recorder which traces on a graph a line representing the strength of the incoming signals.

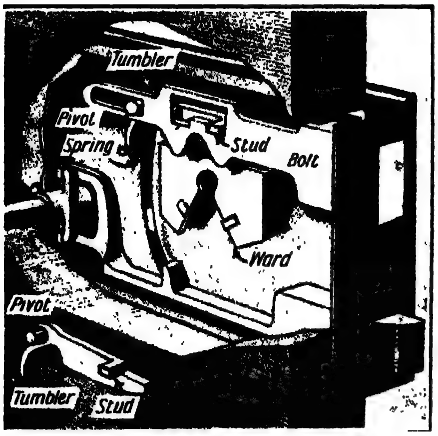
In 1952 construction began of a huge radio telescope for Manchester University. The telescope was jointly designed by Professor A. C. B. Lovell of Manchester University and Husband & Company, a British firm of consulting engineers. The site of the telescope is in the middle of the Cheshire Plain at a place called Jodrell Bank, near Homes Chapel, and the cost of construction, £350,000, was shared by the Nuffield Foundation and the Department of Scientific and Industrial Research.

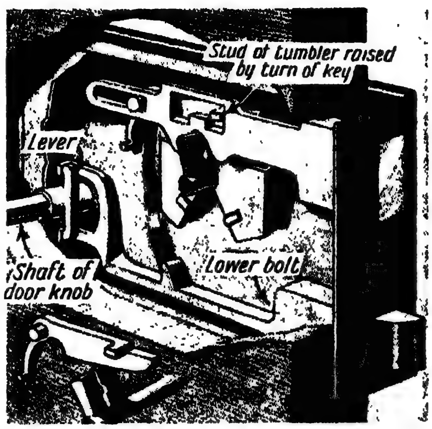
The most striking feature of the telescope is its aerial, an enormous bowl 250 feet in diameter and weighing over 300 tons. The bowl is made of 2-inch steel mesh and in its centre is an upright steel aerial for fixing positions. The bowl is carried on a long girder mounted on two towers so that it can be swung up or down horizontally, the power from the electric motors doing this is transmitted through gear wheels 30 feet in diameter. The towers are carried on four large bogies which run on a circular track 300 feet in diameter. The bogies are driven by electric motors and turn the aerial so that it faces any point of the compass. The aerial can be positioned to any point in the sky to an accuracy of ¼ degree. The total weight of the aerial and its equipment is 1,300 tons and the whole mass can be moved by pressing a button, and the 400 h.p. motors can turn the aerial completely round in 20 minutes.

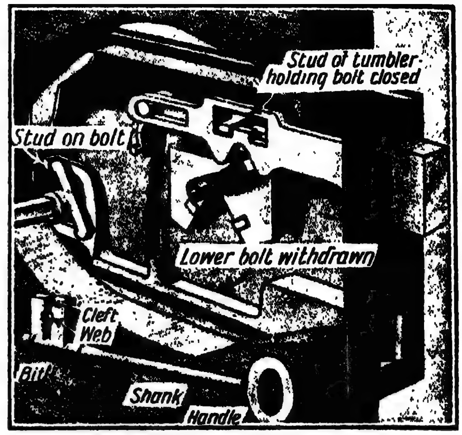
THE LOCK THAT KEEPS THE DOOR SHUT

Locks and keys of some kind have been made by men for thousands of years. They have been found among the remains of Ancient Assyria and Egypt, and in the Old Testament there are references to locks and keys, as when, in the Book of Judges, Ehud locked the doors of King Eglon's ing, when an ornamental gold or silver key is prepared, locks and keys are made not for show, but merely for use.

One of the greatest improvements that have occurred in the making of locks and keys has been the reduction of their size, so that the keys are much more easily carried in the pocket. 200 locks in use? Some are on doors, some on drawers, some on cupboards, and some on boxes. In the old days these would have been very costly to make, and so there would have been far fewer in a house, but now, with machinery, locks can be produced quite cheaply and rapidly.







These pictures show how an ordinary room door-lock works. The key has an opening called a cleft with a round nick—the web—in the middle, as shown in the picture on the right. When the key is inserted in the keyhole and turned, one half of the bit raises a tumbler, which is a pivoted lever held down normally by a spring In the first picture, where the lock bolt is drawn back, the tumbler is behind the ward, but is shown separately below. When the key raises the tumbler a stud on it, which was resting in a notch of the bolt, is lifted, as shown in the second picture, and the bolt, being now free, can be moved by a turn of the key, as in the third picture, so as to jut out and lock the door. As the key is now no longer holding up the tumbler, this falls and the stud drops into the other notch and the bolt is held securely locked. When the door knob is turned its shaft is turned also, and a lever presses on a stud on the end of the lower bolt, drawing this back and allowing the door to be opened

parlour, and the servants took a key to open them.

Those early locks were made of wood, but later came locks of iron, and the Romans have left us many which can be seen in museums and collections. We have Roman door locks and also padlocks.

In olden times locks and keys were made very beautiful, but now, except for the ceremonial opening of a build- Even a hundred years ago a strong door lock had a very big key, but now quite a powerful lock has a key that will go into a purse. One of these modern door locks with its latchkey is shown on Page 81.

We little realise how dependent we are on locks and keys. How many people know that in a good-sized modern house of twelve or fourteen rooms there are probably from 150 to

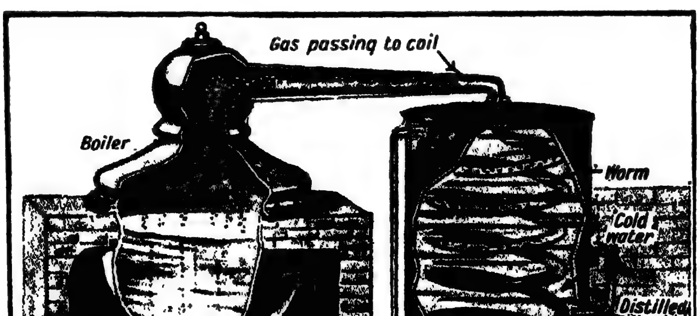
The locks also are much simpler than they used to be, and consist of far fewer parts, so that they do not so easily get out of order. Up to the end of last century nearly all locks were made by hand, and the locksmith was a very important and skilled craftsman. The skill in connection with lock-making has now been transferred from the locksmith to the men who make the tools that make the locks.

WHAT THE INSIDE OF A STILL IS LIKE

Distillation is a process that is used in all kinds of industries and is of the greatest importance in modern manufacture. It may seem a rather long and difficult word but it simply means a trickling down. Why this curious name is given to the process we shall soon see.

We can perform a very simple distilling experiment in the home. When the kettle boils we hold a cold plate or tray against the spout and at once drops of water form on the cold surface and soon begin to trickle down in a stream. That is distillation. It is simply the turning of a liquid into vapour by heat, and then the changing back of the vapour into a liquid by means of cold.

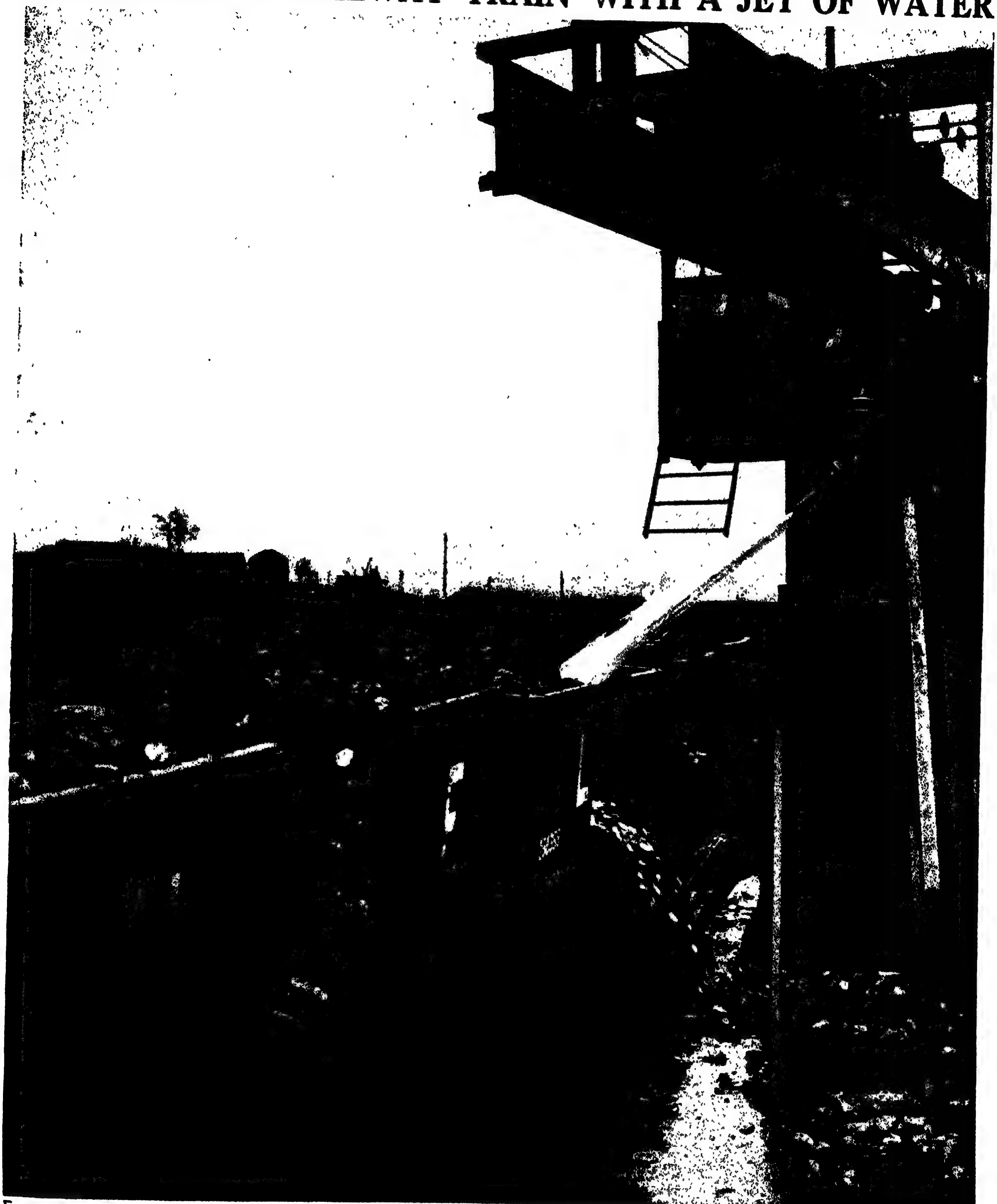
The process is generally carried out in an apparatus known as a still, and its simplest form is shown in the picture here. When water is distilled in this way it is turned into vapour or gas in the boiler, and this passes through a coil or worm round which cold water is circulating and soon the vapour changes back to liquid water and trickles out at the end of the coil. By distilling a liquid we are generally able to get rid of the impurities dissolved in it.



Distilling a liquid by changing it into the gas form by heat and then condensing it back into a liquid by cooling it

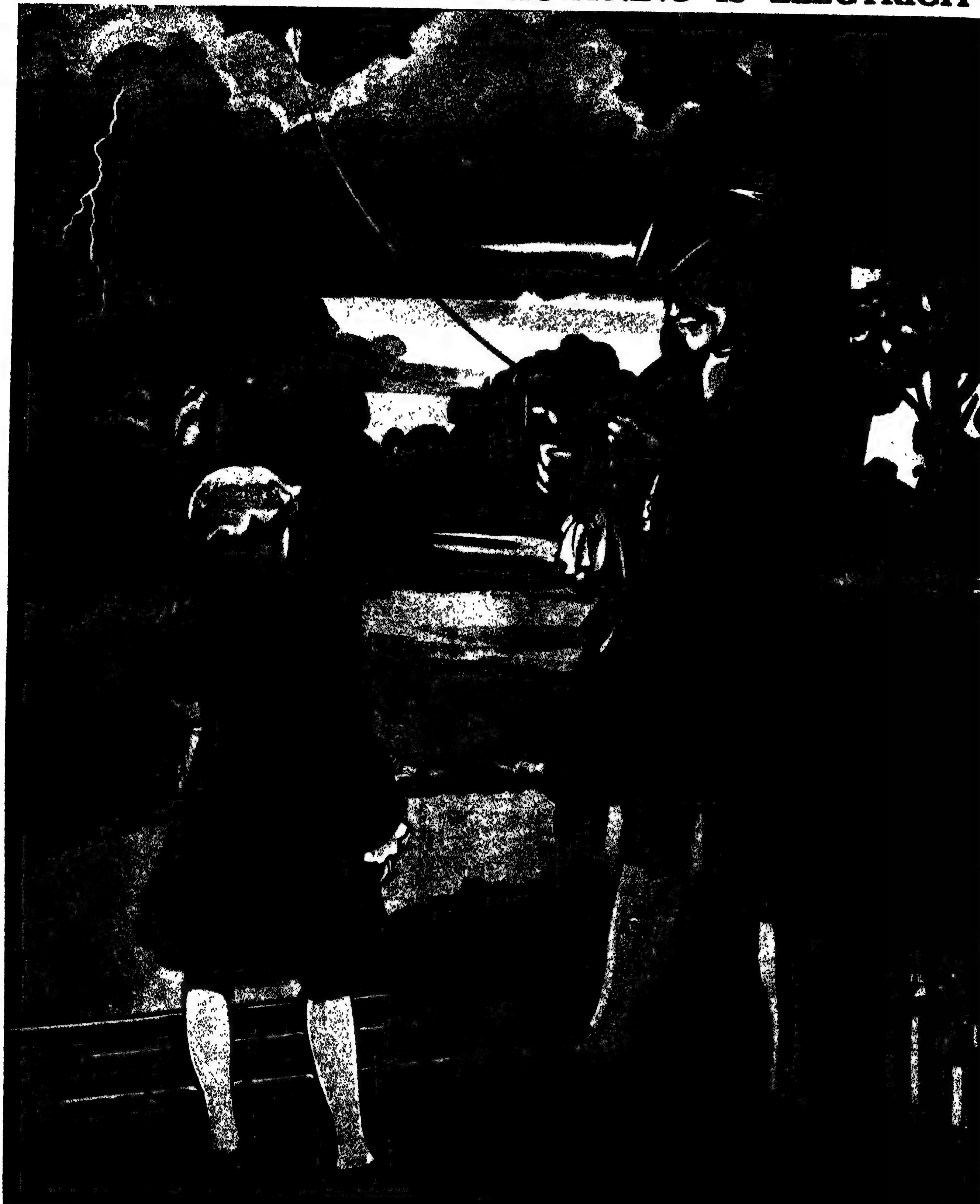
Of course, in industry, distillation is often a complicated process requiring elaborate machinery. For example, a mixture may consist of various substances that change into the gaseous state at different temperatures. Then these leave the boiler at different times as the heat increases, and can be drawn off separately. Such separation is, however, rather rough and ready, and absolutely pure substances cannot be obtained by distillation alone. They have to go through further processes to remove all the impurities.

UNLOADING A RAILWAY TRAIN WITH A JET OF WATER



Enormous advances have been made recently in methods of handling railway stock. The picture on this page shows a wonderful railway device which has recently come into use. It consists of a powerful jet of water which is used for unloading railway trucks of such goods as sugar beet. The side of the truck is let down, as shown in the picture, and when the jet of water is directed upon the contents everything is washed out of the truck in a minute or so. In this way a vast amount of manual labour is rendered unnecessary. Of course, the power of a jet of water under high pressure is very great indeed, and even if this jet is struck with a crowbar the bar cannot be made to pass through, owing to the force of the water, which is then like a solid substance

FRANKLIN PROVES THAT LIGHTNING IS ELECTRICITY



It was Benjamin Franklin, the American, who first proved that lightning was really the same as electricity produced by an electrical machine. During a thunderstorm he flew a kite and on the end of the string he placed a key. For some time nothing happened, but afterwards when he put the tip of his finger near the key an electric spark passed from the metal to his finger, a proof that what he had believed was really a fact, that the lightning was electricity. When Franklin first made this experiment he had only his young son with him, for he feared ridicule in case of failure. This was in 1752, and soon the experiment was repeated in other countries

A CHEMIST'S INVENTION FOR THE HOME

When Bunsen, the German chemist, invented the gas burner that is called after his name, he did so for the convenience of chemical students in university laboratories. He little thought that his invention would prove a boon and blessing to millions of homes, yet without the Bunsen burner we could have neither gas cookers nor gas fires. On this page the interesting story of the Bunsen burner is retold

When we hear of the Bunsen burner, we perhaps think that this is something which concerns only the chemistry class at school and has no relation to our everyday life But we should all be very badly off were it not for the Bunsen burner, which is found in nearly all our homes and, in many houses, is in use in every room.

What is the Bunsen burner? Well, it is a special device for making a gas flame very hot—far hotter than it would be if we burned the coal gas that comes through the pipe from the gasworks without the aid of this device.

When coal gas burns from an ordinary old-fashioned burner it gives a luminous flame, and as we know from blackened ceilings, a great deal of soot is deposited during the burning. We can prove this very clearly by holding a white plate in the gas flame. At once the plate is coated with soot

Soot Brightens the Flame

Now it is really this soot that causes the brightness of the naked gas flame, for the particles of carbon making up the soot become incandescent in the flame and give this its luminosity or brightness

If we have seen hydrogen gas burning we shall know that it gives a practically olourless flame But if we blow fine articles of soot into the burning ydrogen gas, the flame will at once ecome luminous by the incandescence f the carbon particles

If more oxygen be supplied to a coal-gas flame it loses its luminosity, because the flame becomes hotter and the carbon is all burned up. And that is what the Bunsen burner does. It is a device for supplying air, which contains oxygen, to the burner so that this will mix with the coal gas, secure more perfect combustion, and increase the heat of the flame.

Air enters through a hole or series of holes, being sucked in by the current of gas as it rushes from the nozzle at the bottom of the burner. The mixture of air and gas ascends and burns at the top of the tube. The flame is very hot but all parts of it are not equally hot. The central part of the flame, the most luminous, is about 300 degrees centigrade, the tip of that part of the flame is much hotter—about 1,000 degrees, while the almost invisible part outside is as high as 1,550 degrees centigrade

A Bunsen burner showing how air mixes with the gas to produce a very hot flame, the various parts of which are at different temperatures

As can be understood such a hot flame is particularly useful for heating and cooking purposes, and so it is used in gas fires and gas cookers and gas rings in the home, where it is a disadvantage to have the production of soot with the flame. It is really the invention of Bunsen that has made possible the general use of gas in the home.

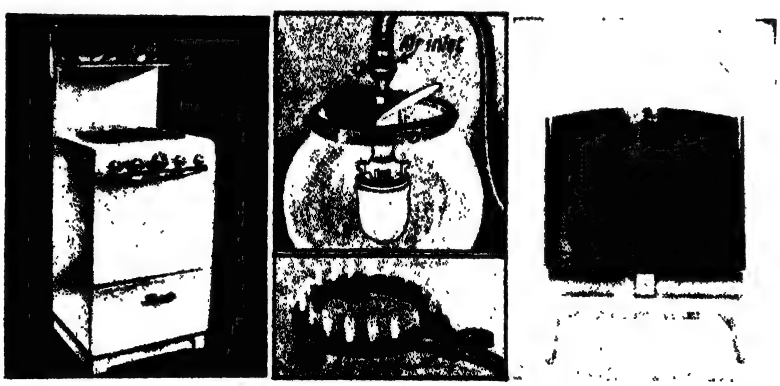
How the Gas Mantle Came

It is the Bunsen burner, too, that is used with the incandescent gas mantle Had this great boon not been invented gas as an illuminant would have been practically dead by now, for compared with the incandescent burner and the electric light, it is not only inferior from the luminous point of view, but produces so much soot that ceilings and walls soon get blackened and need to be whitewashed and papered

A German chemist, Auer von Welsbach, was experimenting with the rare metals of the thorium group when he found that certain compounds became brilliantly luminous when held in a Bunsen flame. The fabric was consumed but the ash gave the bright light. It was the beginning of the incandescent mantle. Welsbach found that a better result still was obtained by adding to the thorium 1 per cent of a compound of cerium, and mantles are now made of those substances

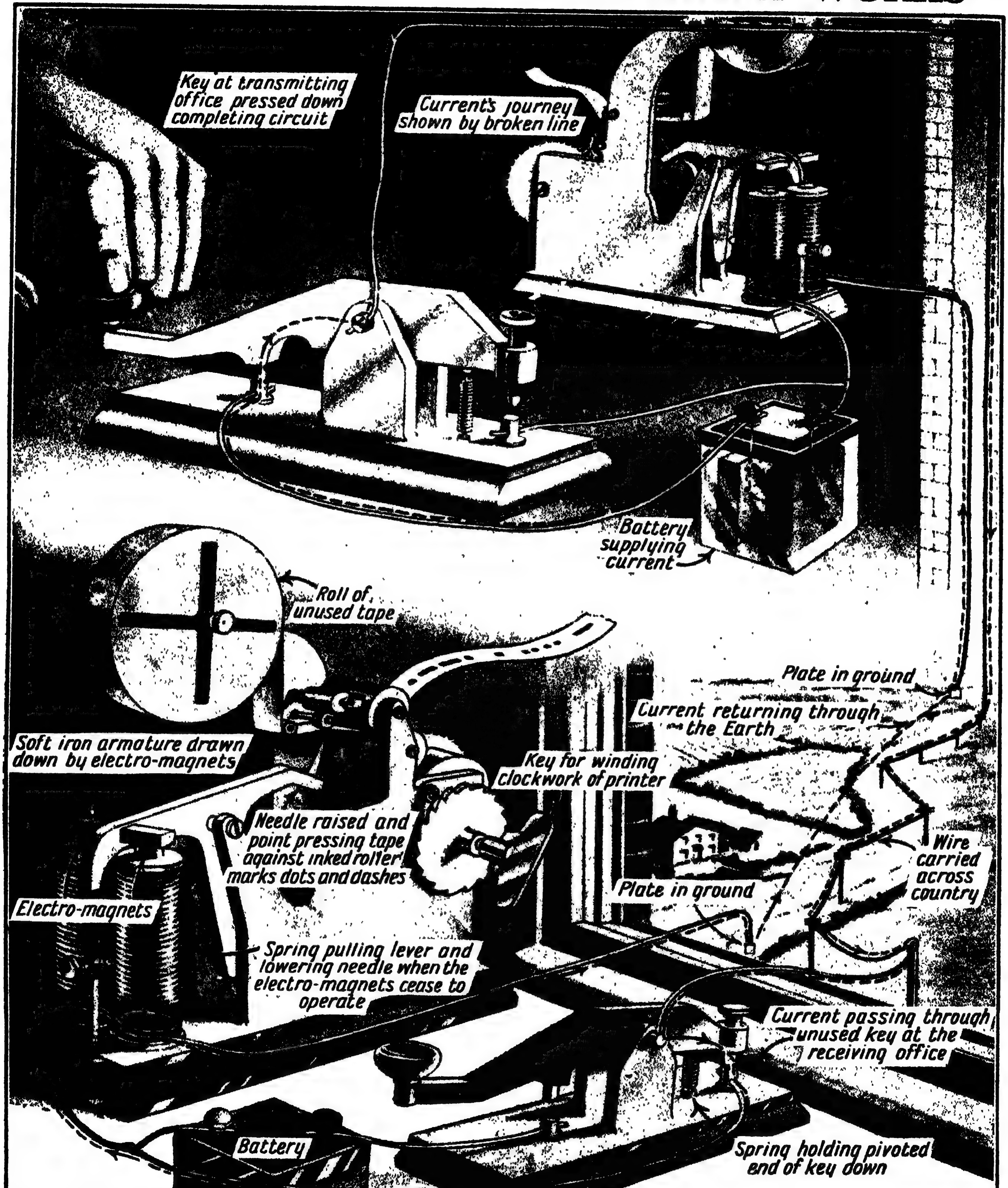
It is interesting to know how Bunsen came to invent the burner that goes by his name. In 1853 Sir Henry Roscoe, the English scientist, took to Heidelberg, where Bunsen was a professor, a gas lamp used for heating purposes in University College, London. It's temperature was often low and Bunsen said: "Roscoe, I am going to make a lamp in which the mixture of gas and air shall burn without any wire gauze."

He made many experiments, and two years later produced his burner



Ways in which we use the Bunsen burner in our homes. Air is burned with the gas to give a hot flame in the gas cooker, the incandescent gas burner, the gas ring, and the gas fire

HOW THE ELECTRIC TELEGRAPH WORKS



The picture on this page shows the principle of the electric telegraph. By pressing down the key at the sending office an electric circuit is completed and the current flows from the battery or other electric source through wires across country to the receiving station, where the current magnetises the iron cores of electro-magnets and attracts a soft iron armature. At the other end of the armature is a needle which presses a paper tape against an inked roller, making a mark. The message is sent in Morse, a series of dots and dashes obtained by the sender pressing his key up and down for longer or shorter periods. The paper tape runs through rollers moved by clockwork. The electric current returns to the other station through the earth. Messages can be sent in either direction. By means of a sounder at the receiving office, messages also can be read by ear, the dots and dashes being reproduced in a microphone

SHELL THAT IS EXPLODED BY ITS TARGET

In sea and land warfare, a shell is exploded by striking its target, the impact of the shell operating a fuse in the nosecap and so firing the explosive charge. If both the gun firing the shell and the target against which it is fired are moving, range-finders allow for the relative speeds between gun and target, so giving a chance for the shell to make contact.

It is a very different matter when guns have to fire at aeroplanes. If a long-range anti-aircraft gun is firing at a fast, high-flying aircraft, the aeroplane will have travelled forward maybe as far as a mile by the time the shell reaches the point where the aeroplane was when the gun fired.

Anti-aircraft shells have time fuses which can be set to explode at any particular time after the shell leaves the gun. In order that the shell shall explode at the right time and in the right part of the sky to hit the aeroplane, a predictor is used to calculate the height of the target, its speed, and the angle at which the gun must be laid for the shell and target to meet by the time the aeroplane reaches the point in the sky where the shell is fused to explode. This information governs the setting of the fuse before the shell leaves the gun.

Nevertheless, even with predictor-controlled fire a shell will explode close to the aeroplane only if the aeroplane continues flying on a straight course. Even a small alteration in course may mean the shell missing its target by several hundred yards.

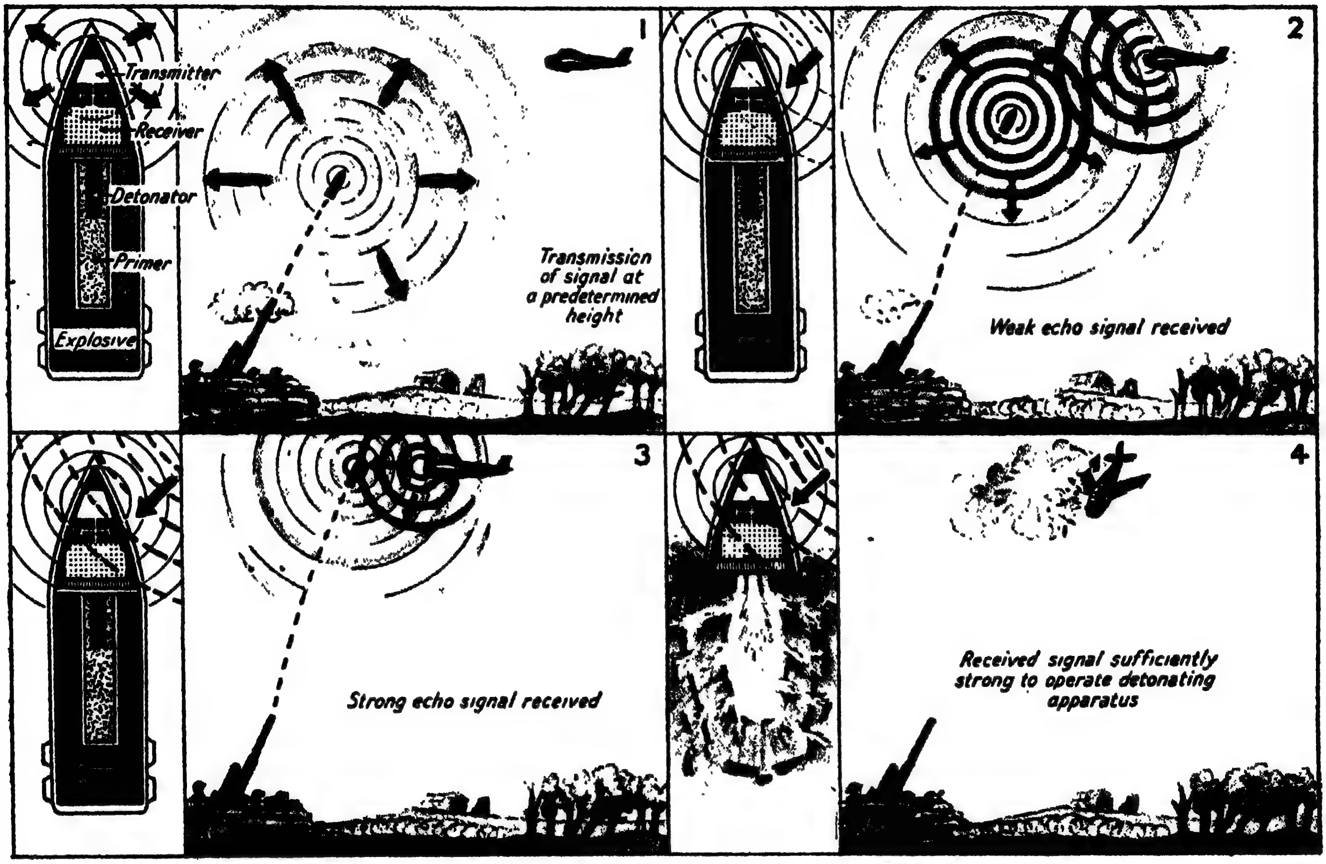
Throughout the First World War and during the first five years of the Second World War, millions of anti-aircraft shells were wasted because they exploded in the sky without damaging the aircraft against which they were fired. Countless thousands of shells passed within a few feet of aircraft without harming them because they had been fused to explode above the height at which the target was actually flying.

Yet if an anti-aircraft shell could be made to explode within even 70 yards of its target there would be a good chance of damaging the aeroplane. What was required, therefore, was a fuse which would automatically explode when it passed near to the aircraft; the only way to do this was to make the aeroplane explode the shell.

Great Britain eventually solved the problem in July 1944, when radio-proximity shells were used against the German flying bomb. In the nose of the radio-proximity shell was a small radio transmitter which sent out radar impulses while the shell was travelling up to its target. When a solid object such as an aeroplane came within range of the radar impulses, the impulses were reflected back to the shell and picked up by a receiver in the nosecap. The impulses were then amplified and caused an electric switch to close, so actuating the fuse.

By adjusting the receiving apparatus it is possible to decide beforehand the distance at which the reflected radar impulse shall explode the shell.

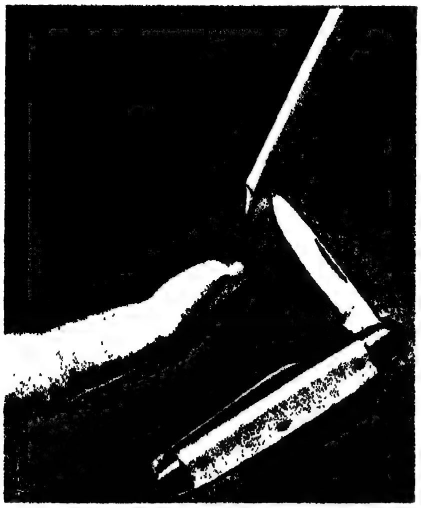
Electric current for supplying the transmitter and receiver is produced by fitting a small propeller only two inches in diameter in the nose of the shell. As the shell travels upwards from the ground the wind pressure revolves the propeller 100,000 times a minute. Attached to the propeller shaft is a tiny dynamo which thus generates the current for the radar transmitter and receiver. Radio-proximity shells incorporate a time fuse so that if the shell is not exploded by passing close to the target it will go off soon afterwards; this prevents it from damaging friendly aircraft or falling to the ground and exploding.



This picture diagram shows how a target explodes shells fired against it. In Fig. 1 the shell has been fired in the path of an approaching aircraft and the fuse is transmitting radar signals. In Fig. 2 the signals have reached the aircraft and are being echoed back very weakly. Fig. 3 shows the aircraft close to the shell, when the reflected signals are strong enough to actuate the fuse. In fig. 4 the reflected signal has exploded the shell and fragments from it have wrecked the aircraft. In the smaller diagrams the unbroken circular lines represent the signals transmitted by the fuse, and the dotted circular lines represent the radar signals reflected back from the aircraft

EXPERIMENTS IN THE ART OF BALANCE

We know that stability of balance depends upon the centre of gravity being low down in a body. The higher it is the more likely is a body to topple over. This is explained fully on page 34.



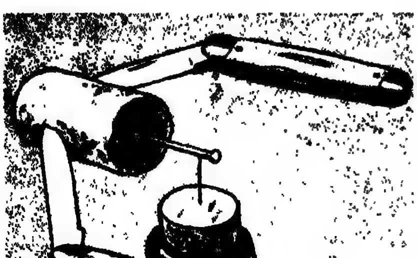
A pencil balanced on its point

Now we can perform a number of very interesting experiments to prove this principle. For example, if we take a well-sharpened lead pencil we can balance it on its point on the tip of our finger. But in order to do so we must use a penknife in the manner shown in the first picture on this page. We partly open the penknife and stick the point of the blade into the pencil. The knife and the pencil then become one object, with the centre of gravity in the heavy handle of the knife, and so the pencil can be quite easily balanced on the finger.

A rather more difficult balancing feat can be carried out as follows: we take an ordinary vinegar bottle cork and stick into its centre a needle with the point uppermost, taking care that the needle is perfectly perpendicular. Then we put the cork into the bottle.

Next we take another similar cork, and put a stout pin into the centre of one end. We then stick the open blades of two penknives of equal weight into the loose cork, one on each side, and adjust the handles in such a way that we can support the pin on the needle-point, as shown in the picture. We open or close the knife blades more or less till the pin rests exactly horizontal.

Now by blowing on the cork that holds the knives and pin we can drive it round on the point of the needle,

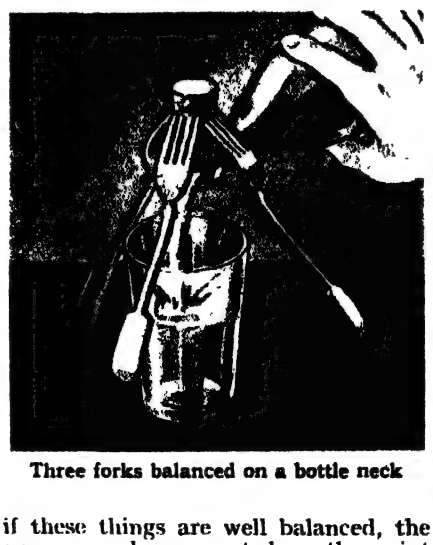


Boring a hole through a pin

A penny balanced on a needle point

and the needle, being of harder metal than the pin, will bore a hole through the pin.

Another good balancing experiment is to spin a penny upon the point of a needle. We bend a hairpin or piece of wire in the shape shown in the picture, and fit one bent end round the penny. On the hook at the other end of the wire we hang a fairly heavy ring. Then



Three forks balanced on a bottle neck

if these things are well balanced, the penny can be supported on the point of the needle, as shown, and by blowing on the ring we can drive the whole combination round. Here again the needle, if sharp, will make a hole in the coin.

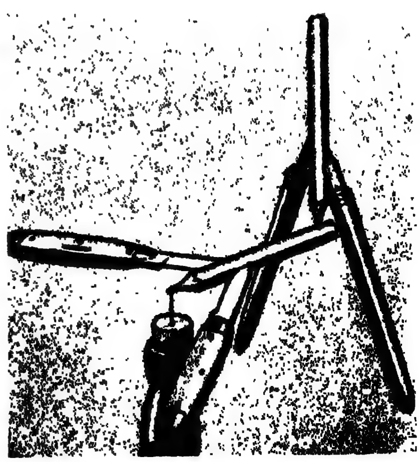
Another experiment is to pour liquid from a bottle with three forks stuck into a cork balanced on the neck.

If we have no candlestick, and yet want to place a lighted candle where it will be safe, we can do this in the way

A glass of water as a candlestick

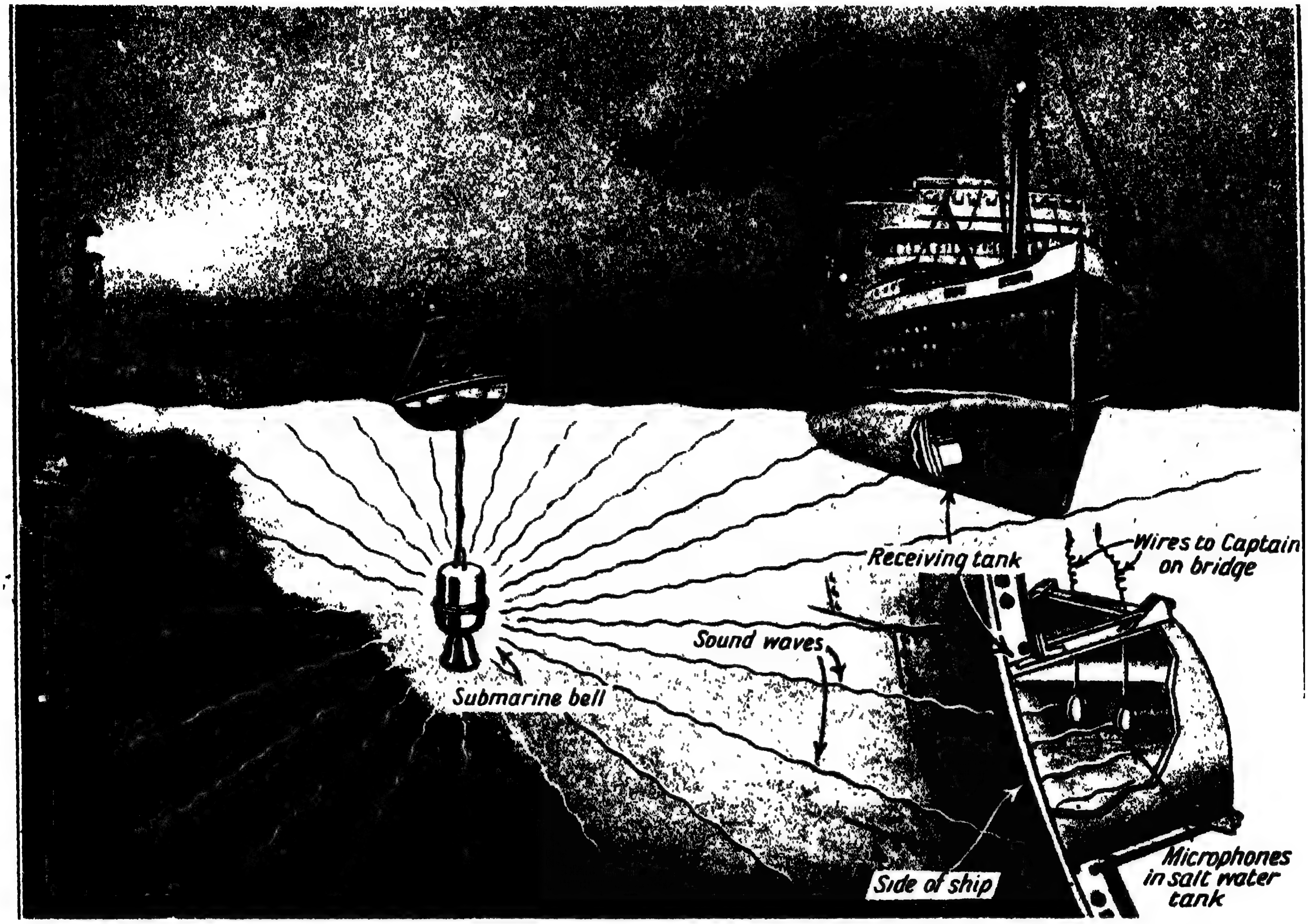
shown in the top right-hand picture on this page. The candle being much lighter than water will float, but it will not float upright, unless we prepare it by lowering the centre of gravity. This we do by inserting a nail in the lower end, which acts as ballast, and brings the centre of gravity low.

There are many variations of these balancing experiments which we can invent for ourselves. The last picture on this page shows another interesting experiment. We stick the blades of two penknives into a black-lead pencil and then balance the lead on the point of a needle in a cork. When this combination is in position, we can balance another black-lead pencil upright on the end of the first one. To do this we stick two pen nibs into opposite sides of the pencil and the penholders then bring the centre of gravity low down, so that it will balance quite easily.



A complicated balancing experiment

THE SUBMARINE BELL THAT WARNS THE SHIP

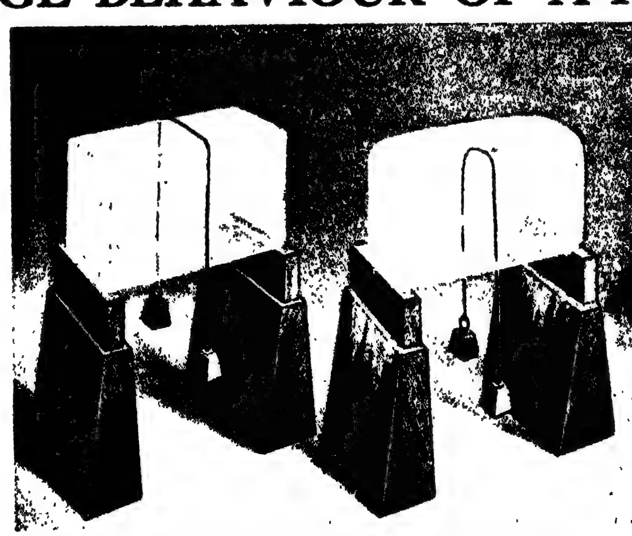


Water is a good conductor of sound, and this fact is made use of in order to warn ships when they are approaching dangerous places. In some parts submarine signals are arranged. A bell attached to a buoy and suspended in the water is rung automatically by mechanism worked by compressed air or electricity. Ships that travel regularly in these parts carry a receiving apparatus. There are two iron tanks in the bows of the vessel, one on each side. These are filled with salt water and the ship's outer plates form one side of each tank. Suspended in the tanks there are microphones connected with telephone receivers in the pilot house. An officer, on placing the telephone receivers to his ears, can hear sounds of the bell even fifteen miles away. By listening alternately to the sound from one tank and then from the other, he can locate the direction of the bell. Sometimes the submarine bell is suspended from a lightship and sometimes from a tripod on the sea bed. Such submarine signal stations are found on the shores of Canada and also in the St. Lawrence River. In the picture the tank with the microphones is shown enlarged in the bottom right-hand corner

THE STRANGE BEHAVIOUR OF A PIECE OF ICE

Why do boys, when they are playing snowballs, take up a handful of snow and press it closely between their two hands before throwing it? They know that this will make the loose snow into a compact ball which will not break up in its journey through the air.

But why does the snow hold together when it is pressed in this way? Well, the great English scientist, Michael Faraday, was the first man to discover the reason. It is due to a principle known as regelation, which means freezing again, a name given to it by John Tyndall. If two pieces of ice, the outside surfaces of which are about to melt, be laid on one another, freezing at once sets in, and the two pieces become one so that if we lift the upper piece the lower one will be lifted with it.

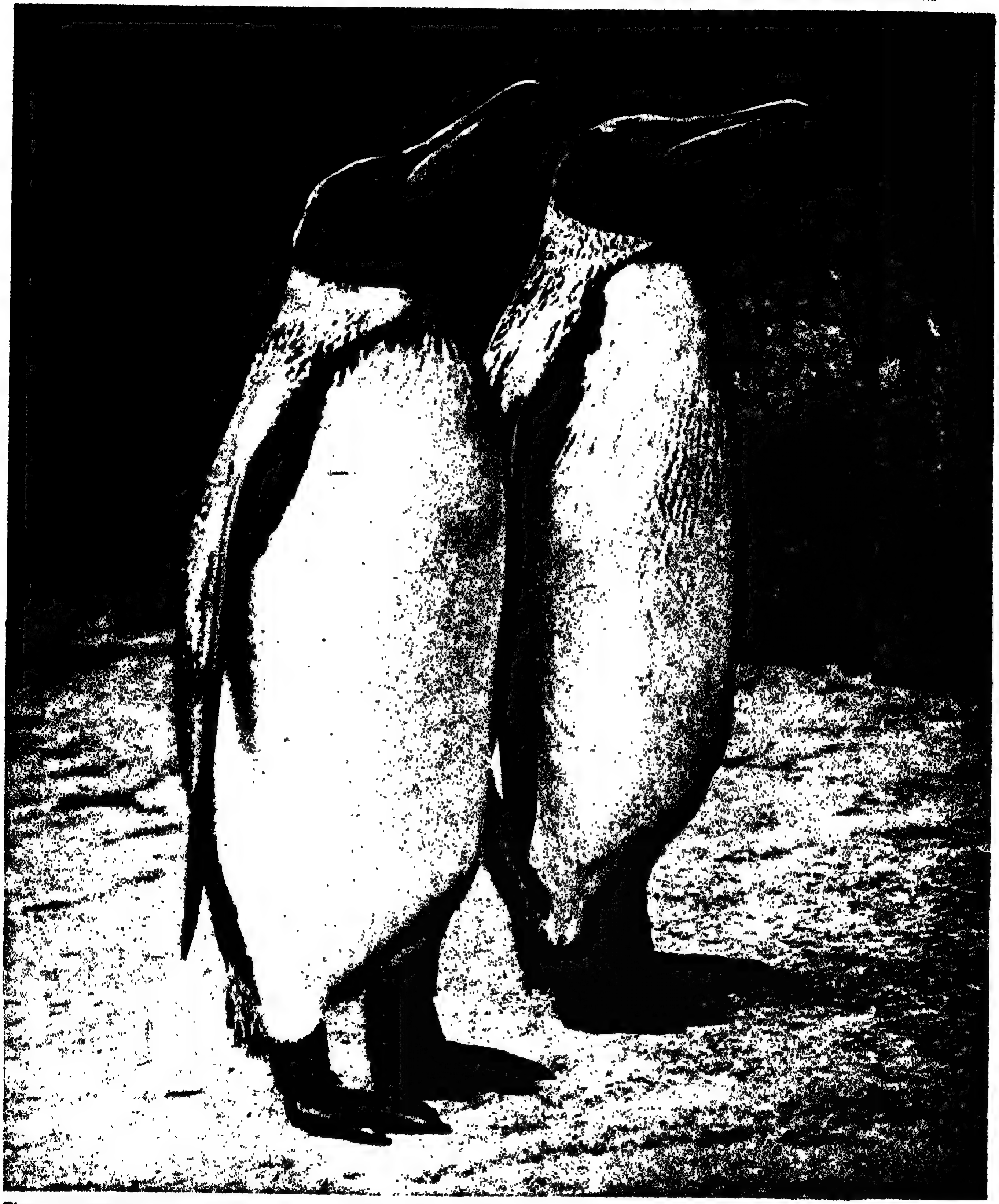


How a string makes its way through a block of ice

We can carry out an interesting experiment to illustrate regelation. If we rest a piece of ice on two supports and then hang over the top of it a string with weights on the two ends, the string will slowly travel through the ice and fall out at the bottom, leaving the ice a solid piece as it was before. The pressure of the string generates sufficient heat to melt the ice immediately under it, but as soon as the string has passed through that part of the ice, regelation sets in and the ice freezes together again. This takes place right through its thickness.

When we pick up loose snow from the ground after there has been a heavy fall and press it together in our hands, the heat caused by our hands and the pressure brings the flakes of snow to the melting-point. Then as the pressure continues the flakes freeze together by regelation.

KING PENGUINS GOING FOR A STROLL



There are seventeen different kinds of penguins and some of them are quite small, but the giants of the family are the King and Emperor penguins of the Antarctic. In this picture we see two King penguins in their customary attitude. They are most amusing birds, for as they strut along in an upright position they look just like rather pompous old gentlemen on their dignity. Their expressions and raised beaks help the illusion. In their native haunts King penguins live on small crustaceans, soft-bodied molluscs, and particularly young cuttle-fish. In captivity, however, they live on fish, but they will never pick up a fish from the ground or even take it from the water, so in zoos they always have to be hand fed by the keepers. One penguin will eat sixty fish in a single day

THE PENGUIN AND ITS QUAINT HABITS

The penguin is a curious bird. It does not fly, it can swim faster than a ship steams, and when it walks slowly and clumsily in a perfectly erect position it looks very much like an old gentleman. But if it gets alarmed it throws itself down at once upon its breast, and pushing itself along with both feet and wings travels at an astonishing rate over the ice. On this page we read many interesting things about the penguin

Of the many varieties of birds that exist none is more quaint in appearance and habits than the penguin. It hardly looks like a bird at all, and when it struts along solemnly, moving the flappers that are the remains of wings, it has the appearance of a very dignified old gentleman, wearing a white waistcoat.

But though the penguins move slowly and clumsily on land, except when they slide down an icy slope, like boys tobogganing, they can move fast enough in the sea, where they are quite as much at home as sea creatures such as the porpoise and dolphin. Indeed, in southern latitudes, when a number of penguins are seen in the water, they are often mistaken for porpoises or dolphins.

Of course they go into the water to get their food, and in collecting it they are surprisingly active. They eat fish, crustaceans and molluscs, and in the hunt go long distances from land. In swimming they keep their feet stretched out behind, and never use them for the purpose of propelling their bodies through the water. It is with their fin-like wings that they swim, and their rate of progress through the water is astonishing. Indeed, they can swim as fast as many other birds can fly in the air. Large parties of penguins have been seen travelling through the waves with a speed surpassing that of a swift ship.

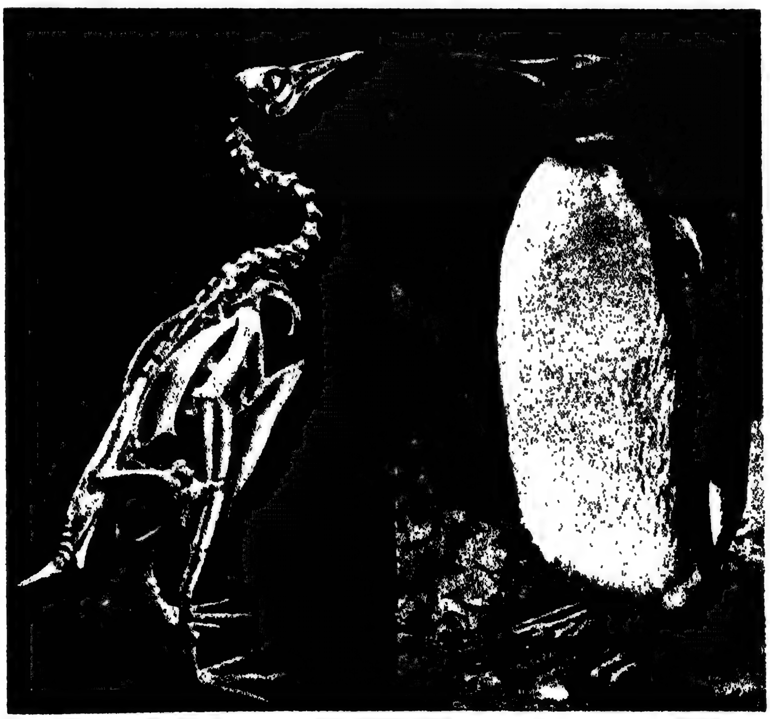
Boat-Shaped Bodies

The shape of their body helps them to travel quickly in the water, as it is the shape of a boat. The penguin has no quill feathers on its queer wings, which are covered with very small feathers, reminding one of the scales of fishes. Their whole structure suggests that penguins are dwellers in the water rather than in the air, and their skeleton corresponds, to a large extent, with their outward form. Their bones are hard, thick and heavy, and do not have air cavities like flying birds.

They are inhabitants of the Southern Hemisphere, but their range extends from the Equator to the Antarctic. It is in the Antarctic, however, that the largest penguins are found. The biggest of all is the emperor penguin, whose home is the icy barrier round about the South Pole. The king penguin, though not quite so large, is found over a wider area. It lives in large numbers in the Falkland Islands, the Straits of Magellan, Kerguelen, and the islands off the south of New Zealand

Class-Conscious Birds

On some of the South Pacific islands as many as thirty or forty thousand penguins have been seen together They arrange themselves in ranks like a regiment of soldiers, and the strange thing is that they divide themselves up into classes, the young birds being all together in one place, the moulting birds in another, the sitting hens in a third, and so on. Sir J. C. Ross tells us that a moulting bird is always driven away by those that are clean.



Here is a living specimen of the king penguin, and a skeleton of the same species. It will be seen that the bones of the body are very thick-set, corresponding with the habits of the bird. But who, looking at the living bird, which seems to have no neck at all, would think that it has the same number of bones in its neck as has the ostrich or flamingo?

The penguin makes no proper nest. Indeed, most of the species make no nest at all The crested penguin or rock-hopper of the Falkland Islands, however, makes a shallow depression in the soil and sometimes lines it with a few stalks of dry grass. Then it lays two greenish-white eggs about the size of those of a duck, and in incubating these both the male and the female take a share. Some other kinds of penguins, however, such as the king penguin, lay but a single white egg, and this is hatched by keeping it close between the thighs. If the bird is approached during the time of incubation it moves away, carrying the egg with it.

An explorer says of the king penguins: "In pride these birds are not surpassed even by the peacock, to which in beauty of plumage they are indeed very little inferior. During the time of moulting they seem to repel each other with disgust on account of the ragged state of their coats, but as they arrive at the maximum of splendour they reassemble, and no one who has not completed his plumage is allowed to enter the community. Their habit of frequently looking down their front and sides in order to contemplate the perfection of their superior brilliancy, and to remove any speck that might sully it, is amusing to an observer.

Fine Feathers

"During the time of hatching the male is remarkably assiduous, so that when the hen has occasion to go off to feed or wash, the egg is transported to him, which is done by placing their toes together and rolling it from one to the other, using their beaks to place it properly. The hen keeps charge of her young nearly a year, and in teaching them to swim has frequently to use some artifice, for when the young one refuses to take to the water she entices it to the side of a rock and pushes it in, and this is repeated until it takes to the sea of its own accord."

STRANGE FREAKS OF PLANT GROWTH

There are plant as well as animal freaks and here are some. 1 and 2 are specimens of fasciated growth in asparagus—that is, where separate parts grow together in fasces or bundles; 3 shows potato tubers growing on a leaf stem; 4, a foxglove with several flowers growing together; 5, a pitcher-shaped pelargonium leaf; 6, twin oak trees; 7, yew leaves growing together spirally; 8, a turnip with leaves growing inside it; 9, a dandelion with many florets; 10, a rose with a stem extended from the blossom; 11, twin mushrooms; 12, a pear with strangely swelled axis; 13, a strawberry with a leaf stem growing from it; 14, a rose with the sepals as leaves; 15 and 16, apple twins; 17, six broccoli heads on one stalk; 18, polyanthus leaves and flowers mixed up; 19, twin teasel flowers; 20, an apple with a swollen stalk; 21, a cabbage with leaves reduced to mid-ribs; 22, a rose with sepals replaced by leaves; 23 and 27, unusual developments of fern fronds; 24, a strange pink; 25, a primrose flower changed into leaves; 26, a fasciated growth of lettuce; 27, see 23

LIFE ON THE EARTH 15 MILLION YEARS AGO

In the left-hand picture we see what life was like in the Devonian period of the Earth's history, about 15 million years ago. Shark-like fishes had increased in variety and size from the Silurian period pictured on page 93. There were other fishes, known as ganoids, with enamelled scales and tails quite different from modern fishes' tails. There were also creatures with partially armoured bodies and toothed jaws. Sea-urchins, molluscs, star-fishes, sea-lilies, corals and sponges all abounded. Plant life was abundant in the sea, and ferns and plants allied to the club-mosses and horse-tails grew on land. On the right we see the life of the Carboniferous period about 13 million years ago. This was when the forests that formed the coal were flourishing. The vegetation consisted of huge ferns, horse-tails and club mosses as big as trees. Insects, myriapods, scorpions, and spiders crawled about, and the sea contained fishes related to our modern skates. But the most notable development was the appearance of amphibian creatures that could live in water and also on land. They resembled lizards and salamanders and one of them, known as the labyrinthodon, was as strong and big as our modern crocodiles

A NUT THAT EXPLODES WITH A BIG BANG

PLANTS have all sorts of ways of insuring that their race shall be carried on, and that the seeds shall be dropped or transported to such situations as shall help them to grow and develop and obtain proper food supplies. Some of these methods we have already seen on pages 10 and 92. In one case they had wings or a parachute which enabled them to travel through the air to suitable places for germination, and in the other examples the seed cases exploded or burst open with a spring and shot the seeds some distance from their parents.

One of the most remarkable of these explosive seed cases is that of a tree that grows in the West Indies and in the tropical parts of South America, and is known to men of science as Hura crepitans. Its popular name, however, is much more picturesque, for it is called the Monkey's Dinner Bell, and we shall see why it has been given this curious name.

A Remarkable Provision of Nature

The monkey's dinner bell produces from its flowers a hard shell which is sometimes called the sand-box nut. The walls of this nut are far too hard for any seed to escape from, in the ordinary way, and so to help the seed Nature has made a remarkable provision.

The Hura tree grows in the thick forests of Guiana and elsewhere, and if the seeds simply fell round their parent tree, as do the seeds of many of our English trees, the soil would soon become overcrowded. The seeds might germinate, but there would not be room for all the trees to grow, and so they would be choked.

How has this difficulty been surmounted by Nature? Well, when the nutshell becomes dry it explodes with a loud report, and the seeds inside are hurled out to a considerable distance from the parent tree. The nut is in fourteen compartments, each containing a single kernel and generally all the compartments of the monkey's dinner bell explode together, so that the kernels are scattered all round. They are thrown to a distance of as much as fifty feet. The explosion is due to the drying and contracting of the cell walls. These are strong, but at a certain point the contraction becomes too great for the strength of the material and the layers of which the cells are composed give way with a jerk and a loud noise.

The Monkey's Dinner Bell nut

At Kew Gardens, where they have monkey's dinner bells, they have to take precautions to prevent explosions which might lead to damage. Some of the nuts are kept in liquid and this, of course, prevents them drying. Others that are allowed to dry are bound round with strands of stout copper wire.

It is the same idea as is carried out when the manufacturer covers with wire those large glass bottles in which we can make soda water in the home. The wire is there to prevent the fragments of glass flying about and doing damage in case the gas explodes the bottle. So the copper wire round the monkey's dinner bell prevents the pieces doing damage should the nut explode.

A Nut Alarms a Household

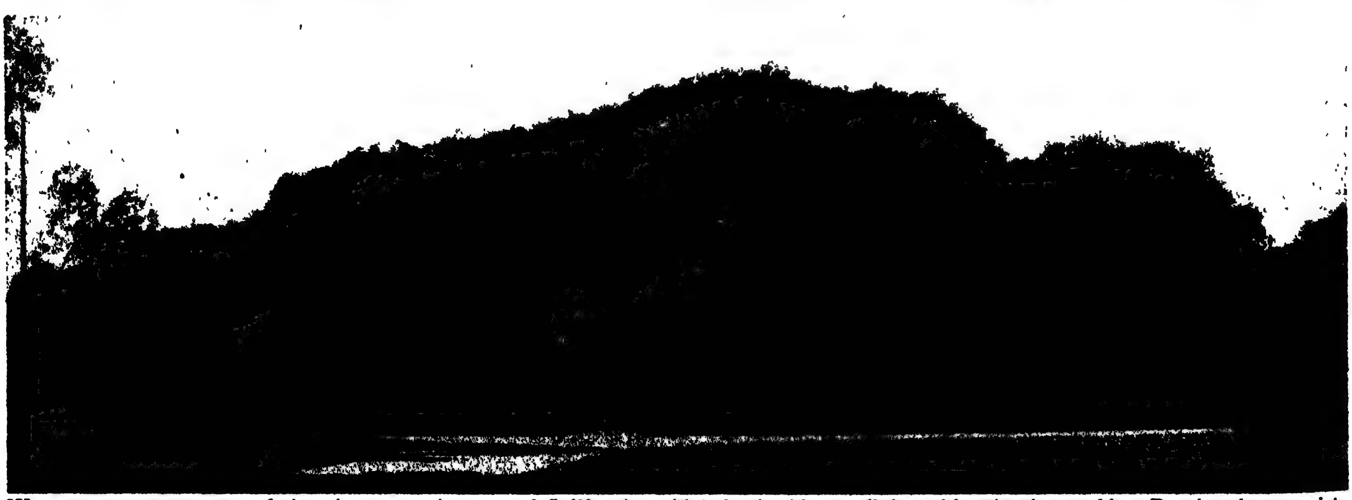
That this strange fruit can do damage has been proved over and over again. Some years ago a gentleman in London received some specimens of various nuts from a relative in British Guiana. Among them was the fruit of the Hura crepitans, which was placed in a glass case on the mantelpiece.

One night the gentleman heard a loud report as though a pistol had been fired. Not only he, but the other inmates of the house were alarmed. The report was followed by a sound of falling glass, and everyone thought that some miscreant had fired through a window. No window was broken, however, but on the floor in front of the fireplace were fragments of broken glass, and on looking up the gentleman saw that the glass case was shattered and the nut missing.

When he came to examine the room, he found all fourteen kernels in different places.

Travellers tell us that when the nut of the Hura crepitans explodes in the South American forests, the report startles the monkeys resting and climbing in the trees round about, and they scamper off in terror, hence the name.

WHICH IS THE BIGGEST TREE IN THE WORLD?



We see on page 59 one of the giant sequoia trees of California, which is the biggest living thing in the world. But its size consists principally in its great height. There are trees which cover a far greater area of ground, and the biggest tree in this sense is the banyan tree, a member of the fig family. It is an Indian tree, and its spreading branches develop hanging roots which grow down, take firm hold of the soil and increase in size. In this way the tree spreads and spreads till some banyan trees have been found with more than 350 stems, each of them as thick as a large oak, and 3,000 smaller stems. The tree shown in the picture is believed to be the biggest banyan tree in the world. It stands in the Botanical Gardens at Calcutta, and under its spreading branches it is said that 10,000 people can gather. The tree is 100 feet high and 857 feet in circumference

THE LIFE STORY OF THE DRAGON-FLY

The dragon-fly, of which there are many species in England, has an iridescent body and gauzy wings. Its life story is a wonderful romance. The female lays her eggs in water, and from the egg there emerges the larva, which is a very bloodthirsty creature that preys on aquatic insects. Directly it sees its prey, a long lip with pincers at the end is poked forward and the victim is seized. The larva breathes by taking water into its body and extracting the air suspended in it. When it wants to escape from an enemy it shoots water from its body, which drives it forward. The larva sheds its skin several times and becomes a kind of pupa or nymph, which, later, changes into the perfect winged insect. When the nymph is ready to do this it climbs a plant, the skin dries and splits, and the dragon-fly emerges and sets off in search of prey. It now has powerful jaws and catches flies, moths and butterflies, tearing them to pieces and eating them. While it can do no harm to human beings or animals, it is a great foe to other insects and therefore a friend to man

THE GREAT DESERT WHERE THE SANDS SING

Strange and mysterious sounds, more or less musical in tone, are sometimes heard by travellers in the desert, coming from underneath their feet as they walk up or down a sandhill like that shown here. Such sounds have been heard in the Sahara, the Desert of Gobi, and the Arabian Desert, and an explanation suggested by one traveller is given on the opposite page. There is no doubt at all that the sounds are due to the movement of the sand particles as these are dislodged by the traveller's feet in his journey over the surface, and the rush of air in or out of the chinks and crevices between the sand grains also has something to do with the matter. The footprints shown here indicate how loose the sand is, and how it must be moved for a considerable depth down when a traveller passes over it on a slope. When the sounds are coming from under the ground the sands at the surface vibrate distinctly till the sounds cease

THE MYSTERY OF THE SINGING SANDS

Have you ever heard the sands sing? It may seem a strange question, but in certain parts of the world there are wide stretches of sand which, as you walk over them, give out more or less musical sounds. There is a great deal of mystery about the phenomenon, but here are some interesting facts about the singing sands

As far back as the thirteenth century travellers in desert regions noticed that in certain places the sands, when walked over, gave out a singing or humming sound. Marco Polo, the Venetian, who travelled in the Far East tells us that, in travelling across the sands of the Gobi Desert, "sometimes you shall hear the sound of musical instruments and still more commonly the sound of drums."

For several centuries this was thought to be merely a traveller's tale, but Sir Aurel Stein, who travelled in the same region in the twentieth century, says, "We all duly heard the faint sound like that of distant carts rumbling."

Strange Sounds

But this strange property of the sands is not confined to the Gobi Desert. British travellers in Persia have heard startling noises from underground when travelling across the desert sands, and one describes them as like the wailing of an Aeolian harp, or the sound occasioned by the vibration of several telegraph wires, very fine at first, but increasing every moment in volume and intensity. It is said that this noise, which often lasts for an hour at a time can be heard in still weather at a distance of ten miles.

Mr. H. St. John Philby, who crossed the great Arabian Desert in 1932, heard the strange sounds, which the natives attributed to evil spirits.

"One warm afternoon," he says, "I was resting in my tent when suddenly I heard an amazing booming sound, very loud and very musical, which lasted about two minutes. It was as if a large number of ships' sirens were being sounded at the same moment.

"I rushed out of my tent to see what was happening, and found that one of my men had set the concert going by walking up a very steep slope of loose sand. I walked up to the top of the ridge myself, and found that I also could produce the same concert effect at will by setting large masses of sand in motion down the hill. Each time the music lasted about two minutes, and stopped when the sand ceased moving down the slope. On one occasion I plunged down the incline after the booming had started, and found that the whole surface of the sand was throbbing and pulsing under me. And when I thrust my arm into the singing mass, and drew it out, it was followed by a deep-drawn wailing sound as of a trombone."

One way in which the singing of the sands may be caused. A vacuum forms between the moving sand grains on top and the stable sand below, and as a traveller dislodges the loose grains by walking, the air rushes in to fill the vacuum, making the strange sounds that are heard

Mr. Philby believes these sounds were produced by the formation of a vacuum between the moving sand on the surface and the stable sand below.

In the peninsula of Sinai there is a sand hill which is known as the Hill of the Bell or Gong, which gives out a sound like that of a humming-top, rising and falling and then dying away. The sound occurs when the traveller is moving over the sands, and it is believed in some cases to be due to the combined sounds of countless grains of sand knocking together as they are dislodged by the pressure of the traveller's foot from above.

A Hum, then a Roar

One traveller tells us that the friction produced between the grains first causes a murmuring hum, which later passes into a roar like that of thunder or the boom of a distant cannon. The sand must be dry to produce this noise, which is always louder in the dry season than when there is moisture in the air.

The sounds vary in different parts of the world. In Hawaii the sand hills are said to "bark," and Hugh Miller, the geologist, declared that on a

musical beach in the little island of Eigg in the Hebrides when he walked he heard a shrill sonorous note, somewhat resembling that produced by a waxed thread when tightened between the teeth and the hand and tapped by the nail of the forefinger. "As we marched over the drier tracks," he says, "an incessant woo-woo-woo arose from the surface that might be heard in the calm some twenty or thirty yards away."

Similar sounds have also been heard at Studland Bay in Dorset, and in Wales, as well as on various European and American beaches.

The sounds on a moist beach by the sea are caused in a different way from those on the sandy tracks of the desert. One theory is that the music is produced by the bubbling of air between the moistened surface of the grains of sand where they have sufficient play to enable them to slide over one another. Another theory is that the sand grains have a thin film of air condensed on the surface, and these films form elastic cushions of condensed gases capable of considerable vibration, which sets up sound waves.

Wherever there are singing sands people standing on them have a curious sensation of vibration. Travellers tell us that there is a tingling in the feet, and sometimes they are even swayed by these vibrations.

The Vibration of the Sands.

Lieutenant Newbold says this happens at the Hill of the Bell in the Sinai Peninsula, already referred to. He heard, he says, first a faint rustling sound, then a low, deep, distant, musical tone, which became more and more distinct and apparently nearer, till at last the fast-repeated notes sounded like those of a deep mellow church or convent bell and the vibrations of a stringed instrument.

When the sands were again disturbed the sounds took up a more treble and prolonged tone, resembling the wild strains of an Aeolian harp, but gradually became deeper and louder till at length they rivalled the continued rumbling of distant thunder. When the lieutenant sat down he felt the sands on which he sat tremble in distinct vibrations.

"The sensations imparted by the vibrations," he adds, "were most extraordinary; I can only compare them with those likely to be experienced by a person seated on the body of some enormous stringed instrument while a bow is slowly drawn over its chords." The sounds and vibrations went on for about a quarter of an hour, and when the last motion of the sand had ceased there was silence once again.

It is not surprising that the natives who live in the regions where the singing sands are found believe that the sounds have a supernatural origin. Lord Curzon tells us that at Kabul the people believe that the sounds of some singing sands in that region are caused by mysterious horsemen shoeing their horses and beating their drums in a great cave somewhere under the ground.

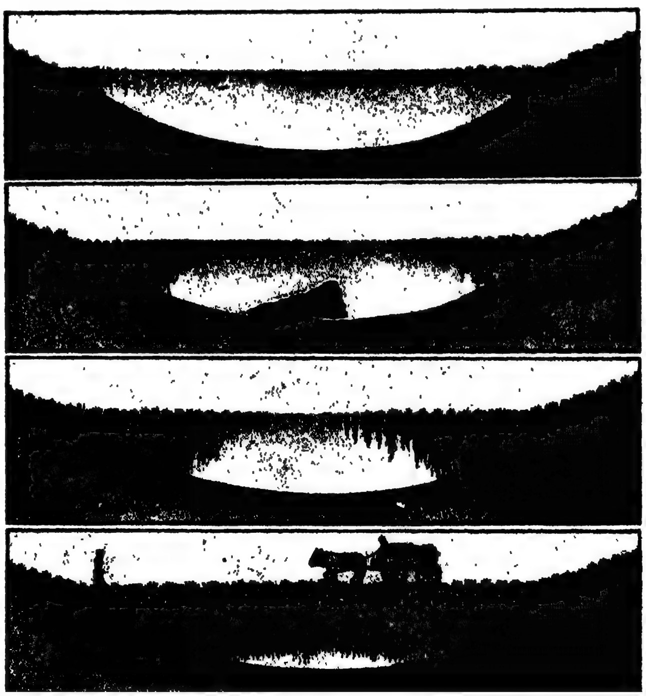
HOW A QUAKING BOG IS FORMED

There are in different parts of the world what are known as quaking bogs. These consist of apparently dry land which will support not only animals and human beings, but loaded vehicles as well. Sometimes, indeed, they will even take a railway. But the surface never becomes quite firm, like ordinary solid land. It always gives a little when heavy vehicles pass over it, and the French call it by the name of "trembling prairie." What is the cause of the quaking, and how does such a formation come into being?

Well, originally the quaking bog was a lake, and on its edges grew a plant known as sphagnum, which is a kind of moss, with long thread-like stems. This moss soon spreads where it gets suitable moist conditions, and while it is living and growing at one end it becomes more or less dead at the other. The dead portions, however, do not decay and disappear, as in the case of many other plants. They simply accumulate, and the stems get packed together tightly until they form a great mass of sponge-like material.

Gradually the sphagnum grows more and more out into the lake, and as the plants perish they form the sponge-like mass already described. At last the whole of the lake becomes filled up with this, and is more or less solid, although it still has the spongy consistency which makes it quake when heavy weights pass across it.

Sometimes huge areas get filled up in this way, although, of course, it takes many years and sometimes hundreds of years to reach the stage of being able to support a wagon road or railway. The mat of sphagnum becomes firmer and firmer owing to the addition of pasty matter that results from the decomposition of other plants. It never becomes so solid, however, that the shaking is not perceptible if one jumps upon it, or a heavy vehicle passes over the surface.



Four stages in the formation of a quaking bog or trembling prairie. A lake becomes filled up with sphagnum moss

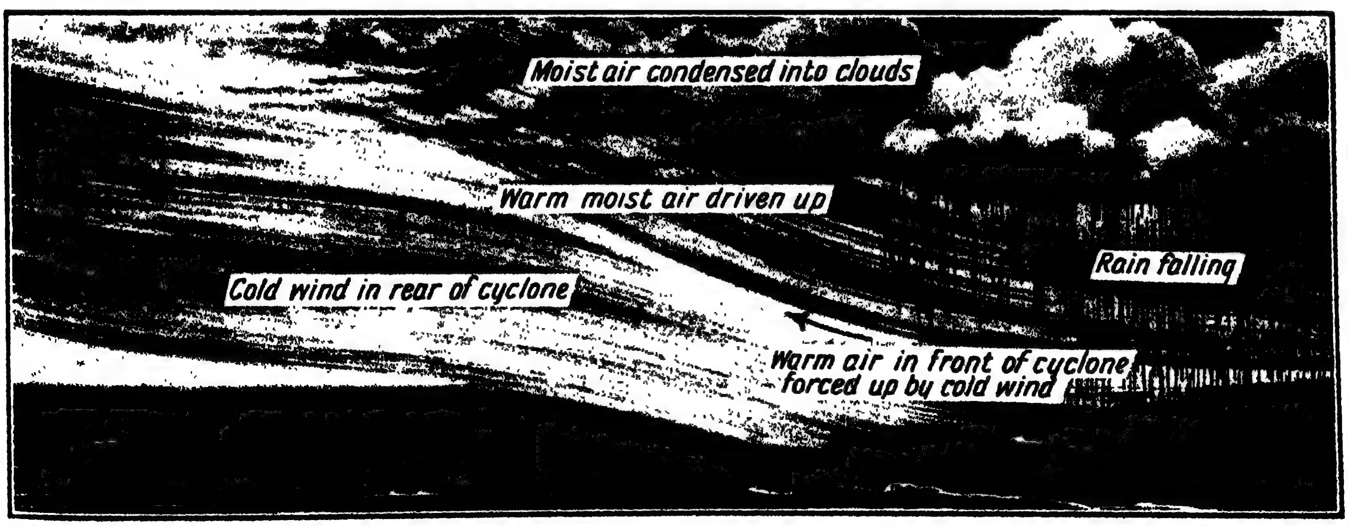
A quaking bog is, of course, quite a different thing from an ordinary swamp or marsh. There is always a tendency for ground to become marshy when the drainage is imperfect, and the difficulties of drainage are due to varying causes. Sometimes the surface of the land is so nearly level that the rain, when it falls, cannot run off, but completely saturates the soil. We find examples of this on the prairies and on the great flood plains of big rivers such as the Mississippi. In the latter case the swamp is known as a river terrace swamp. Frequently there will be a great morass at the mouth of a river, and there, of course, it forms what is known as a delta swamp, or estuary swamp.

But sometimes, on ground that is not quite level, a swamp will form, owing to the accumulation of vegetable matter. In ordinary circumstances the leaves and twigs of the trees and shrubs that grow in a forest, when they fall on the dry ground, quickly decay, and a great deal of the product of decay passes off as gas.

In such circumstances no great amount of solid matter will accumulate, but where the ground is generally wet owing to bad drainage, and the rainfall is frequent, the accumulation of moisture may prevent the complete decay of the fallen vegetation. Then the vegetable matter becomes a fine black slime held together by the masses of fibrous material, and in this condition it is called peat, which, when dried, is a good fuel

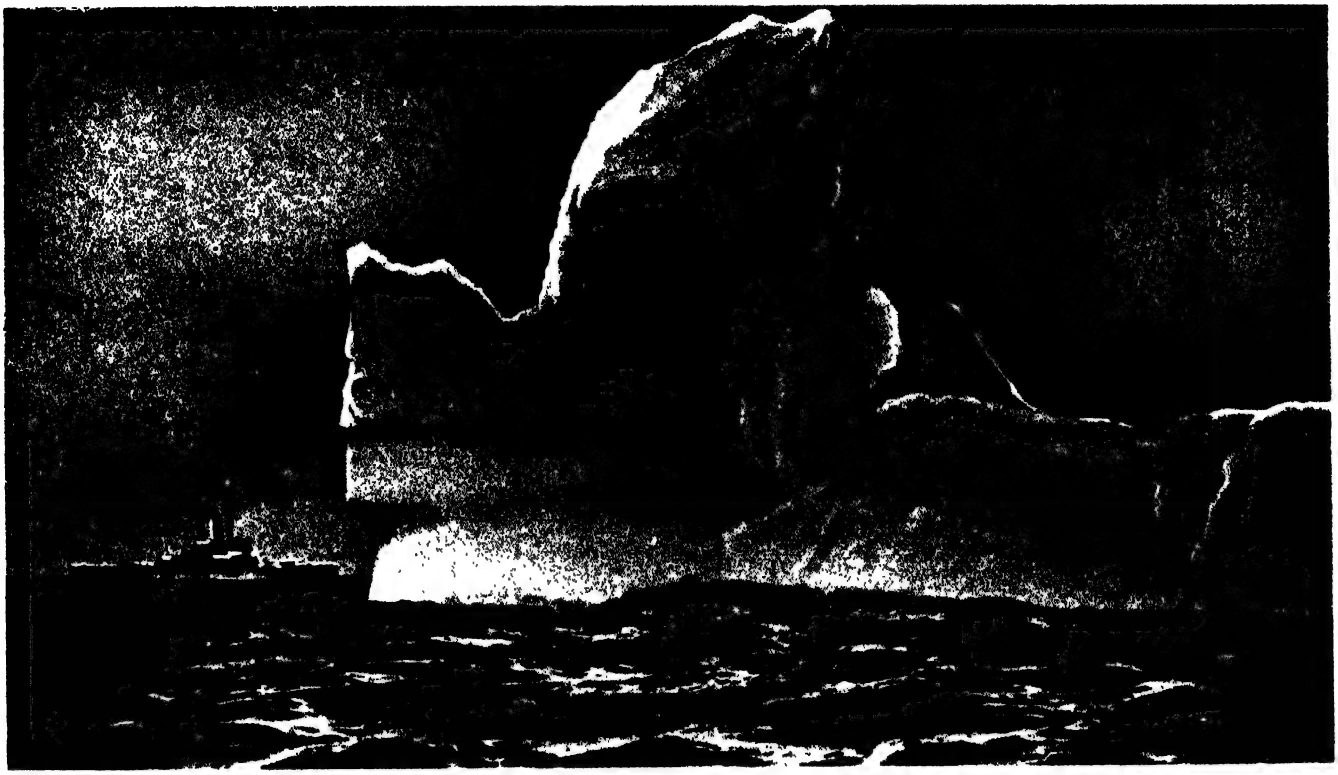
A SIMPLE EXPLANATION OF A CYCLONE

If some of the air were taken from a room the pressure inside would be reduced, and air would rush in through door and windows, till inside and outside were at the same pressure. Something like this happens over large areas. By means not fully understood some air is removed from a region and pressure becomes low. At once air from all round tries to rush in, but owing to the Earth's rotation the inrushing air is deflected to the right in the Northern Hemisphere, so that it moves in an anti-clockwise direction. It is like the water that tries to leave a wash-basin through the plug-hole, and whirls round and round the hole. In the Southern Hemisphere the direction is clockwise. The area of low pressure is called a cyclone or depression, or simply a low. Here we are looking down on a cyclone advancing from the West. In front the barometer will be high and falling, and in the rear of the cyclone low but rising



Here we see a cyclone from the side. The cool air following it meets the warm air from the front and, flowing underneath, drives this up. The warm air is then cooled, and consequently gives up some of its moisture, which condenses and falls as rain. Hence a cyclone brings rainy weather. An anti-cyclone is the opposite of a cyclone. There the high pressure is in the centre and air moves outward

BLOWING UP A HUNDRED MILLION TONS OF ICE



Icebergs at certain seasons of the year are a great menace to Atlantic traffic. Some of the icebergs that float down from the North contain hundreds of millions of tons of ice, and any steamship running into them at full speed would be doomed, as was the Titanic. Here is an iceberg that stood sixty or seventy feet out of the water and was estimated to weigh more than a hundred million tons

There is now a regular International Ice Patrol to look out for icebergs and warn vessels of their nearness. There is also a system by which icebergs approaching the danger zone are blown up with the powerful explosive known as T.N.T. Its proper name is Trinitrotoluene, and it was first prepared in 1863. An iceberg is not entirely destroyed by the explosion, but being broken up into smaller fragments it is less dangerous and, when it reaches warmer waters, melts more rapidly. The Ice Patrol is a boon to Atlantic shipping

AN UNSOLVED MYSTERY OF THE SOUTH PACIFIC: EASTER ISLAND'S STRANGE STONE STATUES

No one knows precisely who carved the 500 huge stone images that stud the hills, roadsides, and cliffs of Easter Island, 2,000 miles from the nearest mainland, the Chile coast. Shaped in one piece from volcanic ash in quarries on the crater of an extinct volcano on the island, each figure has the same long face and distended ear-lobes. When the island was discovered by the Dutch admiral Roggeveen on Easter Day, 1722, many of the statues bore great red hats or crowns, 6 feet high and 5-8 feet across, quarried from crimson tufa rock. Each figure comprises head and torso, but today most of those that remain erect are buried up to the neck in two centuries' accumulation of soil and herbage

THE BLACK PRINCE WINS HIS SPURS

One of the most romantic figures in English history is that of the Black Prince, the eldest son of King Edward the Third, who died before his father and so never mounted the English throne. He was only a boy when he fought at the battle of Crécy and distinguished himself by his chivalry and bravery, and here we read the story of how he won his knightly spurs at the famous battle

JEAN FROISSART, the picturesque historian of the fourteenth century, writes in his Chronicles that "It is a common opinion in England that between two valiant kings there is always one weak in mind and body; and most true it is that this is apparent in the example of the King Edward, of whom I now speak; for his father, King Edward II, was weak, unwise and cowardly; while his grandfather, called the Good King Edward, was wise, brave, very enterprising and fortunate in war."

The reign of Edward the Second, coming between the gallant Edward the First and the brave Edward the Third, who raised England to greater heights of glory than it had ever reached before, was most unfortunate. The people put up with his misrule as long as they could, but at last his barons deprived him of the crown and shut him up a prisoner in Berkeley Castle. The sad thing is that though he was cruelly murdered, few among his subjects regretted the end of such a weak and unwise king as he had proved.

A King of Character

His son, the third Edward, who now mounted the throne, was not yet fifteen, so his mother, Queen Isabella and her friend, Roger Mortimer, ruled the kingdom for a time and very badly they did it. But there was a vast difference between the new monarch and his weak father. As soon as he was seventeen he made up his mind, to take the government into his own hands. Mortimer was sent to London, tried and hanged at Tyburn, and Isabella was taken to Castle Rising in Norfolk and kept a prisoner for the rest of her life, Edward visiting her only once a year.

The new king, a young man of strong character and vigorous determination, was fortunate in having a good wife. She was Philippa of Hainault, and so long as she lived she was a magnificent influence in cooling her husband's outbursts of temper and anger and leading him into paths of mercy. An instance of this occurred very early.

Soon after taking over the government Edward gave a magnificent tournament in Cheapside, London. But during the tilting between the knights the grand stand on which Queen Philippa and her ladies sat gave way Edward at once swore that he would hang the men who had built it, and there is no doubt that he would have done so, but the gentle queen interceded for them and so their lives were spared.

Years afterwards, when the King besieged Calais, it was very bravely defended and this made Edward exceedingly angry. At length the city was forced to surrender owing to famine, and Edward determined to punish the obstinacy of the defenders by making an example of some of the principal citizens. Six of them were to come to him with bare heads and feet, with ropes round their necks and the keys of the town in their hands.

Although many of his own barons and knights pleaded that their lives might be spared, Edward eyed them with angry looks and ordered their heads to be struck off. All the appeals to him for mercy failed, until Queen Philippa, who had come from England to visit her husband, fell on her knees and said, with tears in her eyes, "Ah, gentle sir, since I crossed the sea with great danger to see you, I have never asked you one favour; now I must humbly ask as a gift for the sake of the Son of the Blessed Mary and for your love for me, that you will be merciful to these six men."

The English army resting before the battle of Crécy

The Lady of the Gentle Heart

The King looked at her for some time in silence and then said, "Ah, lady, I wish you had been anywhere else than here; you have entreated in such a manner that I cannot refuse you; I therefore give them to you to do as you please with them."

The Queen conducted the six citizens to her quarters, had their halters removed, clothed and fed them, and then sent them away in safety with a gift of money.

Happy the king of those days who had such a queen, and happy the people with such sovereigns to reign over them.

But we must go back. Any land which has war within its borders is in sad plight, and now began a war between England and France which, with intervals, went on for about a century, and is known in history as the Hundred Years War. First of all Edward sent out an English fleet and for the first time English seamen beat the French at sea. Then, with an army of 30,000 men, he crossed from England and landed at La Hogue. It must have been a great business moving such a large army across the seas in those days of small ships, but the work was carried out successfully.

Odds of Six to One

Unfortunately, as soon as the army landed, sickness broke out and with that and a certain amount of fighting Edward soon had his army reduced to 20,000 men. At last he reached the little village of Crécy, where he halted, hoping that allies from Flanders would join him. But they did not come and to a weak man like his father the prospects of victory would have seemed feeble indeed, for close by, at Abbeville, lay the French king with a great army of 120,000 men. This force not only included a large number of well-equipped and well mounted knights but 15,000 Italian soldiers from Genoa, famous for their skill in using the crossbow.

Everything seemed in favour of the French. In the English ranks, however, were 5,000 of the far-famed English archers with longbows which could shoot much more rapidly than any crossbow, and it was largely on these men that Edward relied for victory.

We are also told, though not by Froissart, that for the first time in history the English used a cannon with gunpowder. If they did it can have done little more than frighten the enemy, although it marks the division between the old form of hand to hand

warfare and the modern method of fighting at a distance with explosives which culminated in the Great War of 1914–18

When Edward reached Crécy, he said to his people, "Let us post ourselves here; for we will not go farther before we have seen our enemies." Then he sent out scouts toward Abbeville who, on their return, declared that there seemed no signs that the Frenchmen intended to make an immediate attack. The French king on his part also sent out scouts to spy out the English position, and they returned with the information that the English were encamped on the plain and were evidently going to await the French attack.

Meanwhile the English army furbished up its arms and repaired its armour. Both kings gave a supper to their lords, urging them to work well together and be brave in the coming conflict. After the meal King Edward retired to his oratory and falling on his knees before the altar prayed to God that if he should combat his enemies on the morrow he might acquit himself with honour. Then, at midnight, he went to bed, but not for long.

An Inspiring Leader

Early the next day he rose, and he and his sixteen-year-old son, the Prince of Wales, went to Mass. This young man, like his father, was full of courage and vigour. He lives in history as the Black Prince, a name given to him probably because he wore black armour. Although recently made a knight, he had not yet "won his spurs," that is, he had not yet done any exploit which should distinguish him as a knight and make him worthy of the gilded spurs which all brave knights wore in those days.

King Edward divided his army into three battalions. The first he placed under the command of the Black Prince; the second was in charge of the Earls of Northampton and Arundel, and the third the King himself commanded. The King then mounted a small palfrey and, carrying a white wand in his hand, rode through all the ranks encouraging and entreating the army that they would guard his honour and defend his right. Froissart tells us that "He spoke this so sweetly and with such a cheerful countenance that all who had been dispirited were directly comforted by seeing and hearing him."

Then the King ordered that his men should eat, and while waiting for the French, sit on the ground, placing their helmets and bows before them in order that they might be thoroughly rested and be the fresher when their enemies arrived.

The King of Bohemia meets his death with all the brave knights whose horses were fastened together so that they might not be parted

Certain knights whom the French king sent out to reconnoitre the English army, when they returned advised him to do as the English monarch had done, namely, to rest his men so that they might be fresh for the fight, for many of them were very tired and in some disorder owing to a long march. The French king, it is said, commanded that this should be done, and sent two marshals to cry out "Halt banners, in the name of God and St. Denis."

There was, however, some confusion in the French army, for while the front ranks halted, those behind continued to press forward and then the front also pushed forward till they came in sight of the English army. But as soon as they saw their foes the Frenchmen fell back in great disorder, and this alarmed the rear ranks, who supposed that they had been fighting and were retreating.

There seems to have been nothing but bad management and disorder in the French ranks, and this was their undoing. As soon as they saw the Frenchmen advancing, the English warriors rose and lined up and the Prince's battalion, which contained 2,000 bowmen, prepared for battle, the men at arms being at the rear of the archers. As soon as the French king came in sight of the English we are told "His blood began to boil," and he cried out to his marshals "Order the Genoese forward and begin the battle in the name of God and St. Denis."

Unlike the English, the French forces did not form in any regular order, but advanced in any way they pleased. The 15,000 Genoese crossbowmen were very tired, having marched on foot that day more than 30 miles. They declared that they were not in a fit condition to do any great things, but the Earl of Alençon, hearing this, said, "This is what one gets by employing such scoundrels who fall off when there is any need for them." This was very unfair, for in ordinary circumstances the Genoese bowmen were brave and excellent fighters.

To add to the discomfiture of the French, heavy rain began to fall, accompanied by thunder, and at the same time, Froissart tells us, there was "a very terrible eclipse of the Sun; and before this rain a great flight of crows hovered in the air, over all those battalions making a loud noise." Such appearances were always regarded as omens in those days, and the tired French forces were scarcely likely to regard them as good omens. Before very long, however, the rain stopped, the eclipse passed, and the battle began.

The Genoese Advance

Unfortunately for the Frenchmen they had the sun in their faces, whereas the English had it at their backs. The Genoese, as was their custom, approached the English with a loud shout in order to frighten them, an early example of "frightfulness," but it took more than a shout to frighten the dogged undemonstrative English who, as the chronicler tells us, "Stood still and stirred not for all that."

Then the Genoese gave another loud cry and leaped into the air, but the English moved not a foot. A third time there was a leap and a cry, and now they shot fiercely with their crossbows. The English archers stepped forward one pace and began to let their arrows fly so hotly and so rapidly that the Genoese were bewildered. An Italian who wrote an account of the battle, referring to the shower of arrows, declared that "it seemed to snow"

The tired Genoese with their heavy crossbows that took so long to load, could stand it no longer. Some, in desperation, threw away their bows, and others cut their bowstrings. All

began to fly from the field, and as they fled they broke in among the large body of French horsemen who were ready to support them. This added to the confusion and the King of France, seeing the Genoese fall back, cried out to his men at arms, " Kill me those scoundrels! For they stop up our road without any reason!" At this the French horsemen rode among the fleeing archers, striking left and right and killing all they could. It was queer behaviour to kill their own comrades in the face of a determined enemy like the English.

The English archers continued shooting vigorously and rapidly, and soon their arrows began to fall among the horsemen, killing and wounding many Then as the confusion grew a number of Cornish and Welsh on foot, armed with large knives, advanced through the men at arms and the archers, who made way for them, and fell upon the French earls, barons, knights and squires, who had fallen from their shot horses and could not get up again because of the weight of their armour and because it restricted the use of the wearer's limbs. The prostrate cavaliers were either stabbed on the spot or dragged off for ransom.

Among the killed was the blind, but valiant King of Bohemia, who was helping the French. When the order for battle was given the blind king called his knights and said: "Gentlemen, you are of my people, my friends and brethren at arms this day; therefore, as I am blind, I request you to lead me so far into the engagement that I may strike one stroke with my sword."

A Valiant Band

The knights replied that they would lead him forward, and in order that they might not lose him in the crowd or he them, they fastened all the reins of their horses together and put the King of Bohemia at their head that he might gratify his wish and advance toward the enemy. All the members of this gallant band, including the king, were slain and their bodies were found on the ground the next day with their horses all tied together.

It is a curious commentary on the life of the period to learn that the English king was afterwards much exasperated at so many French earls and knights being killed. In those days noblemen were regarded as of much greater value than ordinary commoners. How different from the state of things in these days. We heard so much during the Great War of the value and worth of the ordinary "Tommy." In olden days, however, it must be remembered that a slain nobleman or knight was worth nothing, whereas a captured one was worth a great deal, for he could be held to ransom for a large sum.

Meanwhile, what was happening to the Black Prince? Early in the day some French and their allies had broken through the archers of the Prince's battalion and engaged with his men-at-arms. Thereupon the second battalion under the Earls of Northampton and Arundel came to his aid. The help was needed, for otherwise the Prince would have been very hardly pressed. Some of the Prince's force sent a knight in great haste to King Edward, who was posted on a little hill near a windmill. On arrival he said: "Sire, the lords who are about your son are being vigorously attacked by the French and they beseech you to come to their assistance with your battalion, for they fear that if the French numbers increase the Prince will have too much to do."

The Way of Chivalry

To this the King replied: "Is my son dead, unhorsed, or so badly wounded that he cannot support himself?"

"Nothing of the sort, thank God!"

"Let the boy win his spurs," said the king

rejoined the knight. "But he is in so hot an engagement that he has great need of your help."

The King answered: "Now, Sir Thomas, return back to those that sent you and tell them from me not to send again for me this day, or to expect that I shall come. Let what will happen, as long as my son has life; and say that I command them to let the boy win his spurs; for I am determined, if it please God, that all the glory and honour of this day shall be given to him and to those into whose care I have entrusted him."

Noble Father, Gallant Son

The knight, says Froissart, returned to his lords, and related the King's answer, which mightily encouraged them and made them repent that they had ever sent such a message.

At last the battle ended. The French army was broken up and its king had to flee. As soon as King Edward saw his young son return to him victorious he embraced him and kissed him, saying: "Sweet son, God give you good perseverance; you are my son, for most loyally have you acquitted yourself this day; you are worthy to be a Sovereign." The Prince bowed low and humbled himself, giving all honour to the King, his father.

It has been said that it was from the brave blind King of Bohemia that the Black Prince took the famous badge of the three ostrich feathers and the motto Ich Dien, meaning "I serve," which are still the crest and motto of the Prince of Wales. The tradition, however, is probably untrustworthy.

The Black Prince was never to become a Sovereign. After doing exploits in other battles, especially at Poitiers, where he again defeated the French and captured their king, treating him with great courtesy, he fell ill and finally passed away at Westminster to the great sorrow and consternation of the country. Even his enemies grieved for him, and the King of France, whom he had captured at the Battle of Poitiers, had special prayers and services said for him in Paris.

So much was he loved that one of his old fellow soldiers was so heartbroken at his death that he refused to take food, and died a few days later of grief and starvation. It is doubtful if the English nation has ever before or since so mourned the loss of a prince.

A Ballad of Bravery

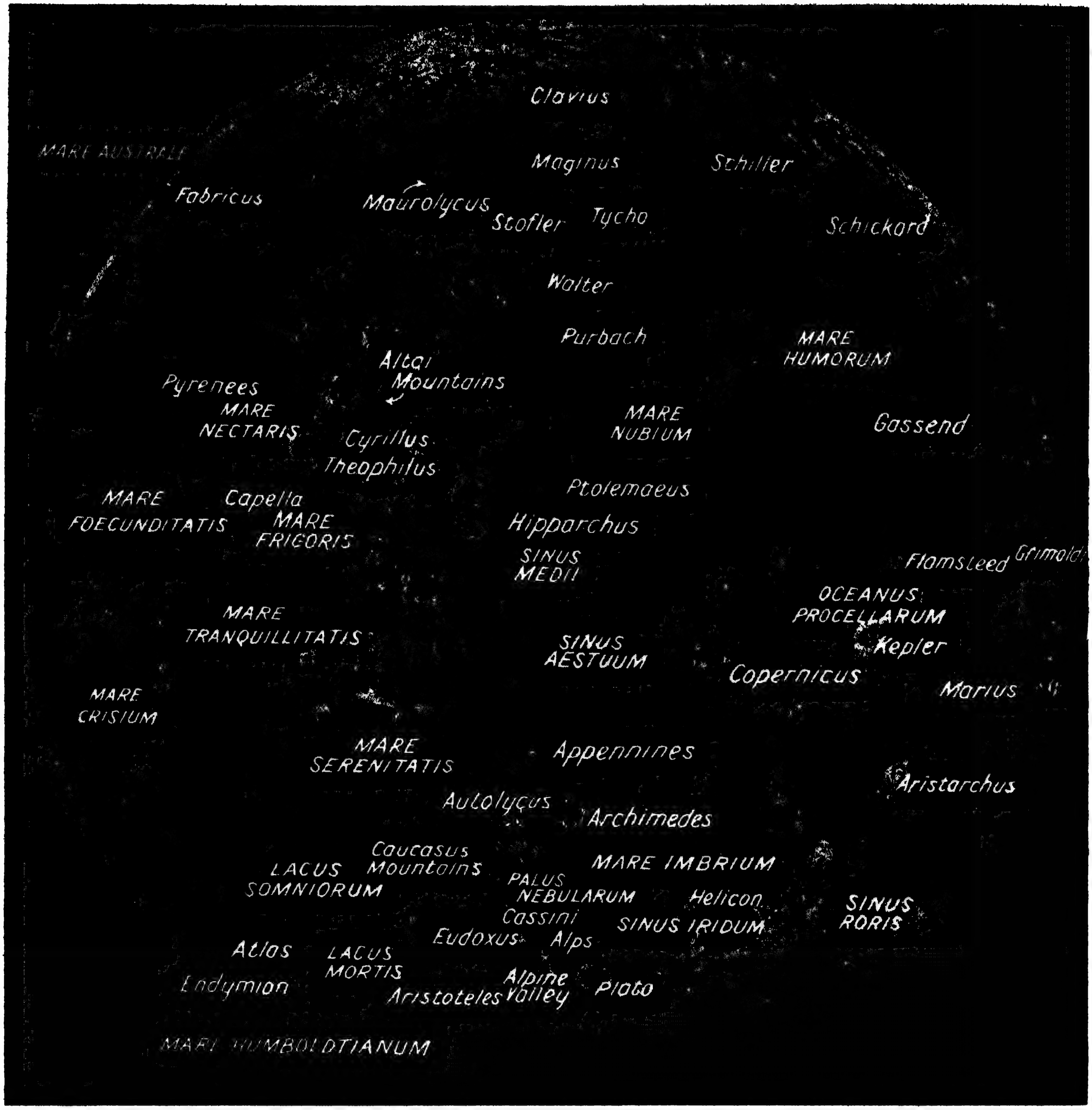
He was buried in Canterbury Cathedral, where we may still see his helmet with the gilded leopard for a crest, his velvet coat embroidered with blue and scarlet, and his shield emblazoned with the arms of England and France.

Francis Palgrave has immortalised the battle and the Black Prince's bravery in his poem Crécy.

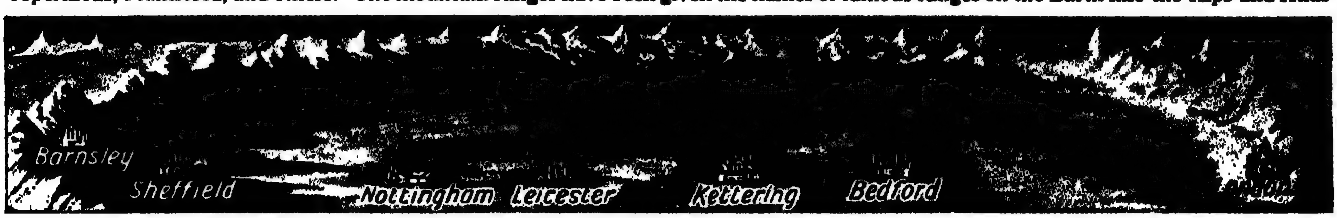
At Crécy by Somme in Ponthieu
 High up on a windy hill
A mill stands out like a tower;
 King Edward stands on the mill.
The plain is seething below,
 As Vesuvius seethes with flame,
But O! not with fire, but gore,
Earth incarnadined o'er,
 Crimson with shame and with fame!—
To the King run the messengers, crying,
"Thy Son is hard-press'd to the dying!"
 "Let alone: for to-day will be written in story
To the great world's end, and for ever:
 So let the boy have the glory."

Pride of Liguria's shore,
 Genoa wrestles in vain;
Vainly Bohemia's king
 King-like is laid with the slain.
The Blood-lake is wiped out in blood,
 The shame of the centuries o'er;
Where the pride of the Norman had sway,
The lions lord over the fray,
 The legions of France are no more:
The Prince to his father kneels lowly:
"His is the battle—his wholly!
 For to-day is a day will be written in story
To the great world's end, and for ever!
 So, let him have the spurs and the glory.'

THE MOON'S FACE WITH ITS GIANT CRATERS



The Moon's surface is quite unlike that of our Earth. Not only is there, so far as we can judge, no water and no vegetation, so that all is dry and desolate, but the face of the Moon is pitted all over with giant craters, far bigger than anything on the Earth. Some of these are as great as 160 miles in diameter. The Moon's surface has been carefully mapped and all its mountains, plains and craters have names. Some of the chief of these are shown here. The plains are called "seas," because Galileo thought they were seas, and his names, in Latin, are still used—Mare Serenitatis, the Sea of Serenity, and so on. Many of the craters are named after famous astronomers Copernicus, Flamsteed, and others. The mountain ranges have been given the names of famous ranges on the Earth like the Alps and Atlas



This picture will give some idea of the gigantic size of some of the Moon's craters. It represents Maurolycus, which is 160 miles in diameter and could contain all the country from London to Barnsley in one direction, and London to Exeter in another direction. Its circumference, if it were placed in England, would run round Wolverhampton, Burton-on-Trent, Peterborough, Cambridge, Chelmsford, Gravesend, Littlehampton, the Isle of Wight, Christchurch, Salisbury Plain, Newport, Radnor, and back to Wolverhampton.

THE STRANGE SCENERY OF THE MOON

The Moon is made of the same materials as the Earth, but its appearance is very different from that of our world of life and colour and beauty. It is a dead and desolate world, and its landscape is dotted all over with mysteriously huge craters surrounded by walls of mountain peaks. Here we read some interesting things about this dead world and its strange surface

If we could travel to the Moon we should find that its surface was very different indeed from the surface of the Earth. In the first place, so far as we know, there is no water on the Moon, although some astronomers think that it is not impossible that there may be solid water in the form of ice on some parts of the Moon's surface, at a temperature too low to evaporate and give off vapour.

When seen from our Earth with the naked eye the Moon is a very beautiful object with its bright disc and soft markings. But seen through a powerful telescope the surface is found to be pitted all over with what are described as craters, and to have mountains and mountain ranges in all parts.

Amazing Craters

On the Earth there are many mountain ranges, like the Alps and Carpathians and Andes and Himalayas, but on the Moon the ranges are far fewer in proportion. It is the extraordinary craters which are the outstanding feature of the Moon's surface. The largest craters on the Earth are not more than seven miles in diameter, but on the Moon, which is so much smaller than the Earth, there are many craters fifty or sixty miles across, and some are as great as 150 miles in diameter.

If we stood in the middle of one of these giant craters on the Moon, we should be unable to see the great mountain peaks that formed the surrounding wall of the crater.

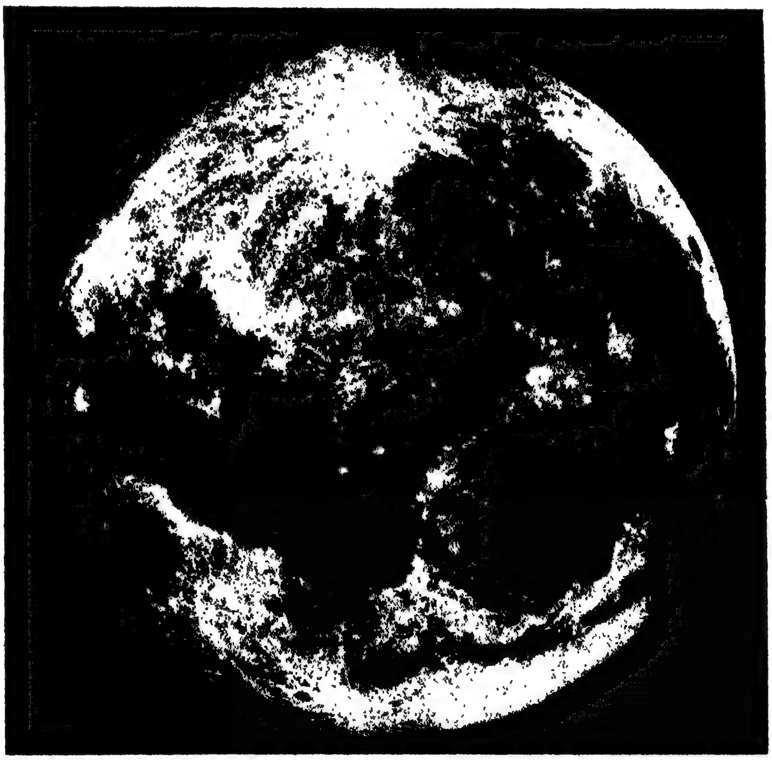
Craters from five to twenty miles across can be counted by the hundred.

These craters are circular in form, the wall all round being really a ring of mountain peaks rising in some places to 20,000 feet above the surrounding country. This is an enormous height for such a small world as the Moon. If Mount Everest were as high in proportion as some of these mountains of the Moon, it would have to be about twenty miles high instead of rather more than five miles, as it actually is.

A curious thing about these lunar craters is that in the centre a group of peaks rises up to a height as great as the surrounding wall. Sometimes the inside of the crater wall is very deep, 8,000 feet or more below the level of the plain from which the crater rises. Some craters, indeed, are 10,000 feet deep. Others appear to be filled up to the brim, so that the floor is far above the level outside. Here and there is a crater which is a mere hole in the surface of the Moon, and has no surrounding mountain ring.

It is interesting to note that these mountain heights and depths on the Moon can be measured even more accurately than can such mountains of the Earth as the giant peaks of the Himalayas. The measuring is done by means of the shadow cast by the mountain or crater wall when the Sun is shining upon it at an angle. The measurements are checked by taking fresh measurements when the Sun is shining and casting the shadow in a different direction.

These strange formations on the Moon's surface are very mysterious. They are supposed to be actually volcanic craters because of their remarkable resemblance to similar formations on the Earth. It is not, however, absolutely certain that the Moon's craters are of volcanic origin, although this explanation is the one most favoured by astronomers. Some think that the craters are really pit-marks made on the Moon's surface when it was in a plastic state by meteorites which have struck it as the Moon crossed their path.



The Moon fourteen days after new Moon, photographed at Lick Observatory. Here we can see quite clearly the "rays," or light coloured streaks radiating from the crater Tycho, at the top. These are a mystery to astronomers Of course, in a photograph taken through a telescope, the Moon always appears inverted

Mysterious Cracks

In addition to these craters and a number of mountain ranges not unlike those on the Earth, there are also what appear to be deep narrow cracks that have been given the name of "rills," because it is thought they may at one time have been water-courses. Then there are clefts about half a mile wide, and of an unknown depth, which run across the Moon's surface for hundreds of miles.

Still another feature of the Moon's surface consists of what are called rays, which are light-coloured streaks radiating from some of the craters in all directions. These are often hundreds of miles long, and range from five to ten miles in width. Like the clefts, they go straight across valley and mountain, and sometimes actually through a crater.

Their nature is unknown, although some astronomers have thought that they may be vapours arising from rifts that are too narrow to be visible.

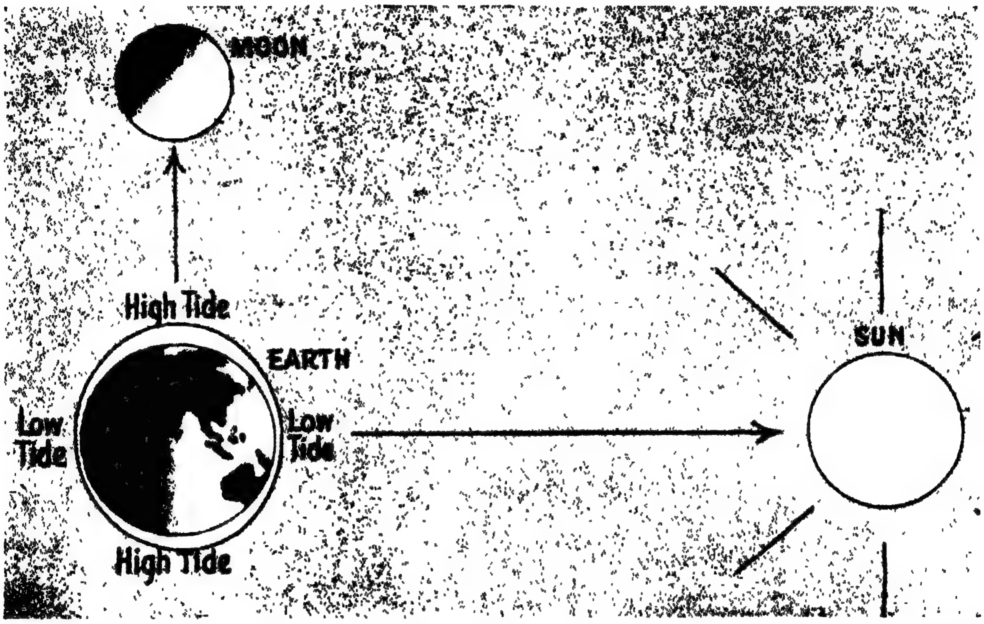
HOW THE TIDES OF THE SEA ARE CAUSED

We are all interested in the tides. When we go to the seaside for a holiday one of the first things we do is to find out the time of high tide and low tide, and we notice great differences on the beach when the tide is in, and when it is out.

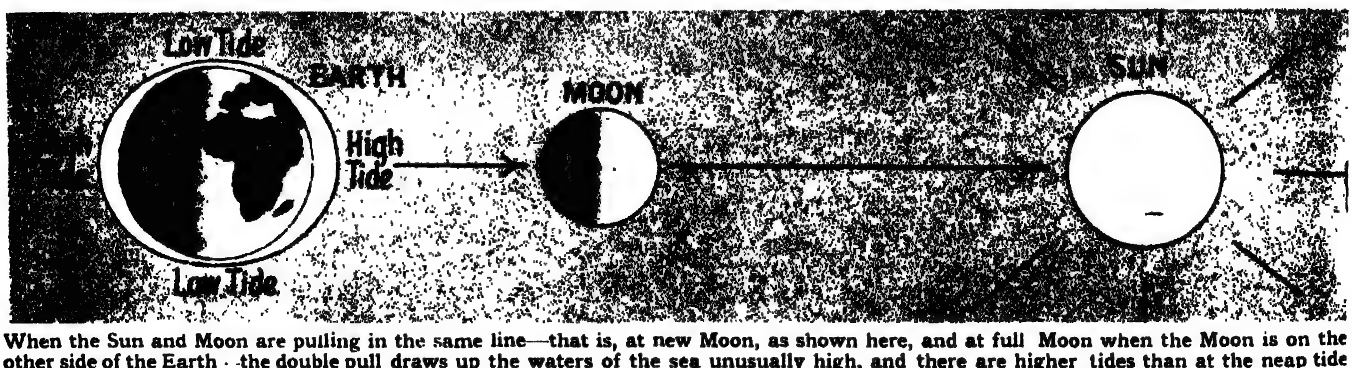
Often when the tide is out the sands are uncovered for a mile or more, and the sea seems very far away, while at high tide there are sometimes no sands to be seen, for they are quite covered by the water which reaches right up to the rocky cliffs.

What is it that causes the tides? Well, they are caused chiefly by the Moon. It was suspected two thousand years ago that the Moon had something to do with the matter, but not until Sir Isaac Newton's time were the tides fully understood.

Gravitation is the attraction which one body has for another, and just as the Sun attracts the Earth, so the Earth attracts the Moon and the Moon attracts the Earth.



When the Sun and Moon are in this position relative to the Earth—that is, when the Moon is in its first quarter—we have what are known as neap tides. At these the sea does not rise so high as at the spring tides, explained below, for the Sun and Moon are pulling the waters of the Earth's seas in different directions, and so the two pulls to some extent counteract one another. The same thing happens when the Moon is in its third quarter



When the Sun and Moon are pulling in the same line—that is, at new Moon, as shown here, and at full Moon when the Moon is on the other side of the Earth—the double pull draws up the waters of the sea unusually high, and there are higher tides than at the neap tide position shown in the upper picture when Sun and Moon are pulling at right angles to one another. These high tides are called spring tides

This attraction shows itself as a pull. The Earth pulls the Moon and the Moon pulls the Earth.

Now, owing to this "pull of gravitation," the Moon, as it travels round the Earth, pulls the part nearest to it more than it does the centre or the other side of the Earth. This pull does not have much effect on the solid part of the Earth, but the waters of the sea, being fluid, are drawn up into a bulge, and where that happens there is high tide.

Even the solid Earth yields a little to the Moon's attraction and has very small tides. The waters on the opposite side of the Earth are more distant from the Moon than the centre of the globe, and so they are not attracted as much as the solid earth, with the result that they also become bunched up into a high tide. They are, as it were, left behind when the solid Earth is pulled towards the Moon.

But the Sun also pulls the Earth and draws up the waters opposite to it. If there were no Moon we should still have tides caused by the Sun's attraction. Now the Sun, being so much bigger, should pull the waters up much more than the Moon. Yet it does not do so. Why is this?

Well, in the first place the Sun is so much farther away that much of what it gains by size it loses by distance. It is 26,648,000 times as great in mass as the Moon, but it is 389 times as far away, so that, taking both facts into consideration, it should pull the Earth with 175 times the force that the Moon has. And this it actually does.

Why, then, are the tides caused by the Sun less than those caused by the Moon? The explanation is that the tides are due not merely to the pull itself, but to the difference between the pull on the centre of the Earth and the pull on the sides nearest and farthest from the Sun or Moon.

Now as the Earth's diameter is 8,000 miles the sides of our globe nearest to and farthest from Sun or Moon are 4,000 miles nearer or farther than the Earth's centre. This figure is a much greater proportion of 240,000 miles, the Moon's distance, than of 93,000,000 miles, the Sun's distance, and so the difference of the Moon's pull on the different parts of the Earth is much more noticeable than the difference of the Sun's pull on the various parts.

When Sun and Moon pull together, as shown in the lower picture on this page, the tides are higher than when they pull against one another, as in the upper picture.

Of course, the time and the height of the tide vary in different places according to the nature of the region. The shape of the coast affects the tides.

HOW WASHING CLEANS OUR CLOTHES

We all know that things are made clean by washing, whether it be hands and faces, or cups and saucers, or our clothes. But why does washing make things clean? On this page the matter is explained, and we also read how machinery has been adapted to the work of the laundry

UP to fifty or sixty years ago most of the washing of the household linen was done in the home. Sometimes the maids carried out the work, and sometimes washerwomen visited the home and did the laundry work on a special day each week, which came to be known as washing day.

It was not the pleasantest day of the week, especially in damp weather when it was difficult to dry the clothes. In those homes which had no proper garden or drying ground the clothes had to be hung up in the kitchen to dry. The whole house was pervaded with the odour of soap-suds and the dampness which resulted from the steam and wet clothes was not particularly healthy, especially for any people who had weak lungs

Washing is still done in the homes of many people, but it is a less laborious task than it used to be. There are many appliances which lighten labour, and which are not very expensive. The majority of homes, even the most humble, contain at least a mangle, and to run the wet clothes through the mangle, squeezing out the water, is far less strenuous work than to twist the clothes up and wring the water out by hand.

But in large numbers of homes the bulk of the washing is not now done in the house. The heavier articles, like sheets and blankets and tablecloths are sent to laundries, and only the smaller things are washed at home; for these there are home washing-machines.

An Industry Employing Thousands

The washing of clothes and household linen has developed into a huge industry, employing tens of thousands of people. At first the work was done largely by hand, but laundries are now equipped with a great variety of costly machinery, so that the clothes are handled very little. Even the so-called hand laundries do not do the work by hand in the old sense of rubbing and wringing the articles without any machinery at all.

In the early days of laundry machinery, before the various appliances had been perfected, there was a good deal of destruction of linen. Buttonholes were torn, cuffs were wrenched off shirts, tablecloths and sheets were torn, and even holes caused by chemicals were not altogether unknown. Now, however, a well-equipped laundry does its work amazingly well, and there is little more destruction of the fabric than when the linen is washed by hand.

We all benefit by the work of the laundry, but how many of us have ever stopped to think why it is that washing clothes makes them clean? The tablecloth has something upset on it, and has a dirty patch. The collar when we take it off at night is grimy, and the apron or towel becomes soiled after a little use. Then the article is washed and dried, and mangled and ironed, and if the work has been done properly it is as spotless as when it was new. What has happened?

Well, the whole science of laundry work is that the stains and grime are dissolved in the water and pass away down the sink. The process of solution is assisted in various ways. The water is made hot, which makes it capable of dissolving substances more easily. It has soap put with it, or in some cases soda, and this still further helps the dissolution of grease and other matter that make the linen dirty.

When the clothes reach the laundry they are marked according to their owners and then sorted. Handkerchiefs are put together, towels together, and so on, and these are placed in compartments in a cylindrical cage, which is closed and then put inside a horizontal drum, in which it can revolve.

The cage with its contents then turns round and round at high speed in the drum, which is supplied with hot water and soap and with high pressure steam. The rotation of the cage in the drum, with the consequent throwing to and fro of the clothes, has the same effect as the primitive method of washing, in which women place the wet clothes on a stone or on a rough board under water, and rub or beat them, to make the water dissolve the dirt and carry it away.

In the case of the more dainty fabrics, which might be torn by rough usage, these are placed in washbags or nets before being put into the washer cage. The washing machine has inlet and outlet pipes, so that the water can be changed rapidly, and one great advantage of the high pressure steam used at a laundry is that it not only assists in washing the clothes, but also sterilises them.

Whirling the Wet Clothes Round

Sometimes the clothes are also bleached to make them white, and the rinsing and blueing (which is another rinsing in blue-coloured water to prevent the white clothes from looking yellow) and the starching, are also done in machines of the drum type.

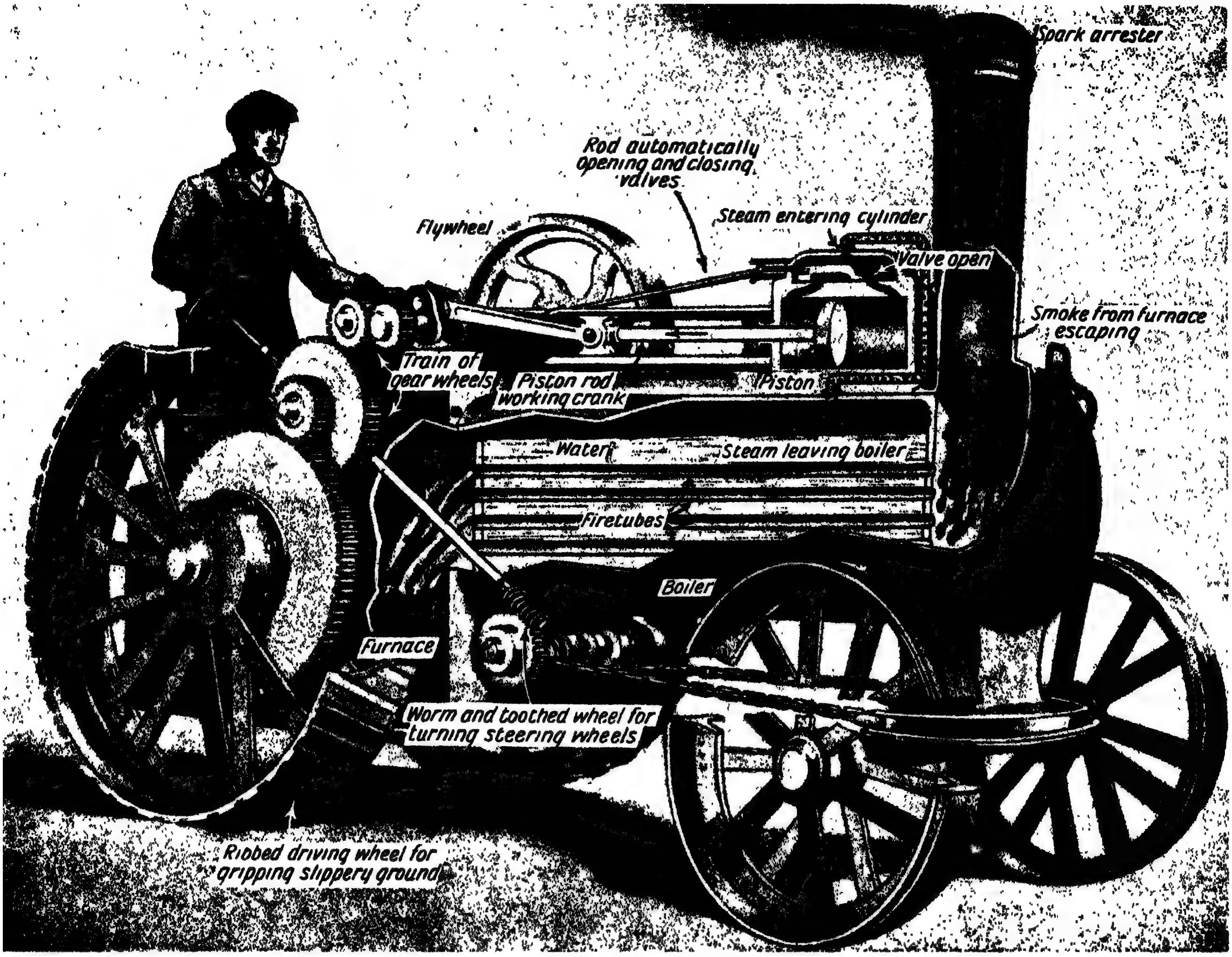
It is the machinery used for drying, however, which is the most ingenious of all that is used in the laundry. To get the water out of the clothes an entirely different principle is used from the old-fashioned wringing. In that process, whether it was done by hand or by means of rollers, the water was squeezed out. But the driers now used in laundries are known as centrifugal driers.

In these the wet clothes are placed in a metal basket or perforated drum, which is revolved at a very rapid rate, and as the clothes are whirled round the water is thrown out of them by the power of centrifugal force, and hurled through the openings in the drum.

The drying is finished in heated chambers, and mechanical ironing follows.

Wet clothes are dried in laundries not by wringing, but in centrifugal driers. They are whirled round in a perforated drum, as shown here, at 1,400 revolutions a minute, and the water is hurled out

HOW A TRACTION ENGINE TRAVELS



In this picture we are shown the inside of a traction engine, and it is easy to see how it works. Steam is generated in the boiler and enters the cylinder through a valve, in the same way as the steam enters the cylinder of a locomotive. It drives the piston forward, working a crank and setting in motion a train of gear-wheels, which are connected with the great driving wheel of the engine. This has a very wide tyre, which is ribbed, so as to enable it to grip the ground and carry the engine forward. A large flywheel regulates the motion. As the piston goes to and fro it also works a rod which automatically opens and closes the valves on each side of the cylinder, thus enabling the steam to exercise force, first on one side of the piston and then on the other side. In the picture the valve is shown open in front and the steam is entering the cylinder and driving the piston back. The driver steers by turning a wheel, which operates a worm and toothed wheel. The shaft of this toothed wheel is linked by chains with the front wheels of the engine, and the driver is able to turn them to the right or left as desired. A steam roller is worked in the same way

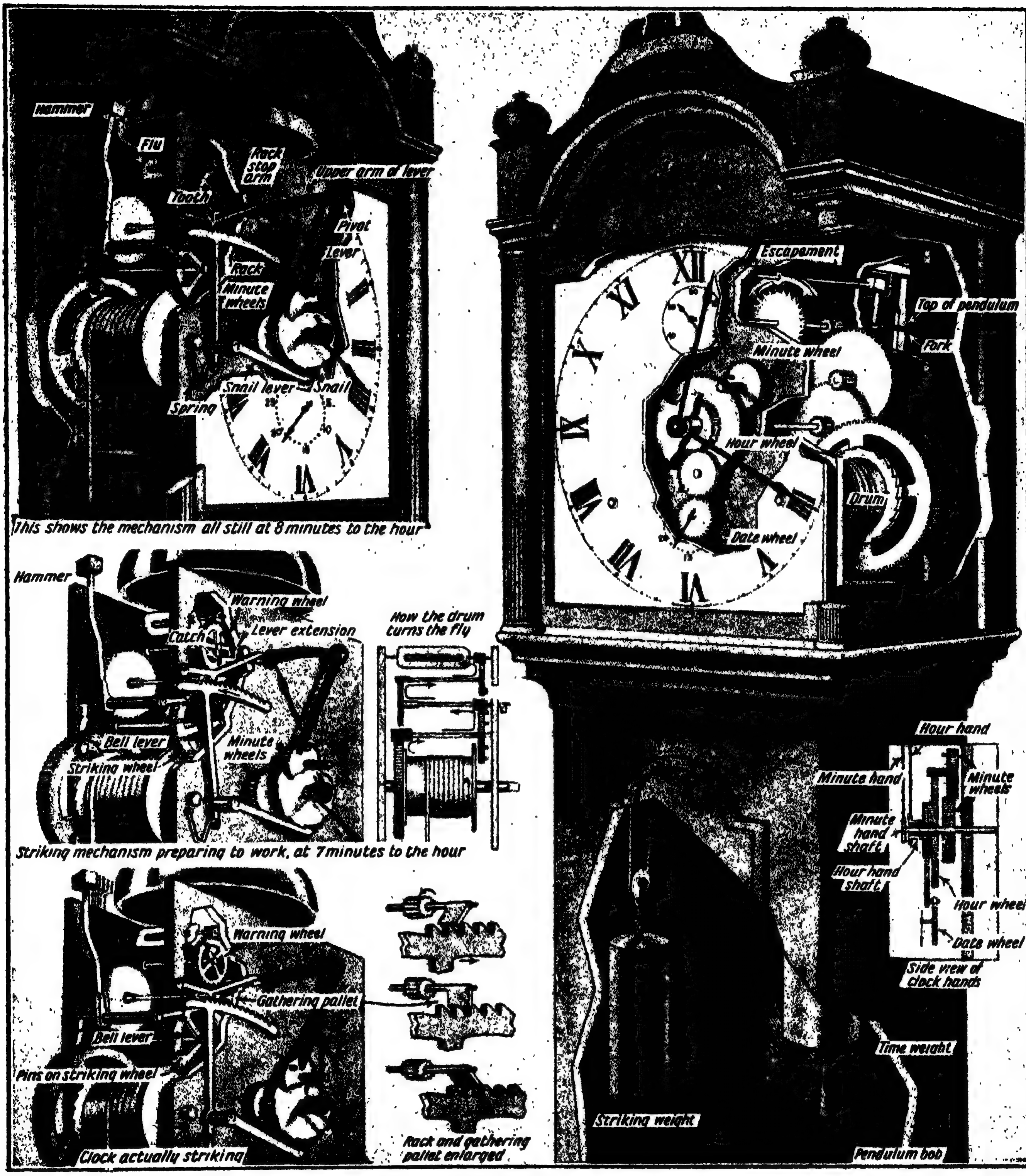
TRAILER THAT CARRIES 700 TONS OF EARTH A DAY

A trailer that holds 30 tons of earth and has 16 wheels.

During the construction of the Cajalco dam in Southern California, enormous quantities of earth had to be moved across rough ground to build an earth embankment over 1,000 yards long. Engineers designed and built a special trailer called a "carry-all." This type of vehicle, now extensively used for carrying heavy loads in constructional work, has a capacity of 30 tons and is mounted on sixteen pneumatic-tyred wheels. It is drawn by a crawler tractor fitted with a 100-horse-power diesel engine and can be towed across rough ground at ten miles an hour.

The body of the trailer is of steel and mounted on a central hydraulic ram which can tip it for emptying to right, left, or rear. The ram is controlled from the driving seat of the tractor so that the trailer can be emptied without the driver's leaving his seat. Several of these trailers were used in the building of the Cajalco dam, and during a working day each moved an average of 700 tons of earth, gravel, or sand.

HOW A GRANDFATHER CLOCK WORKS



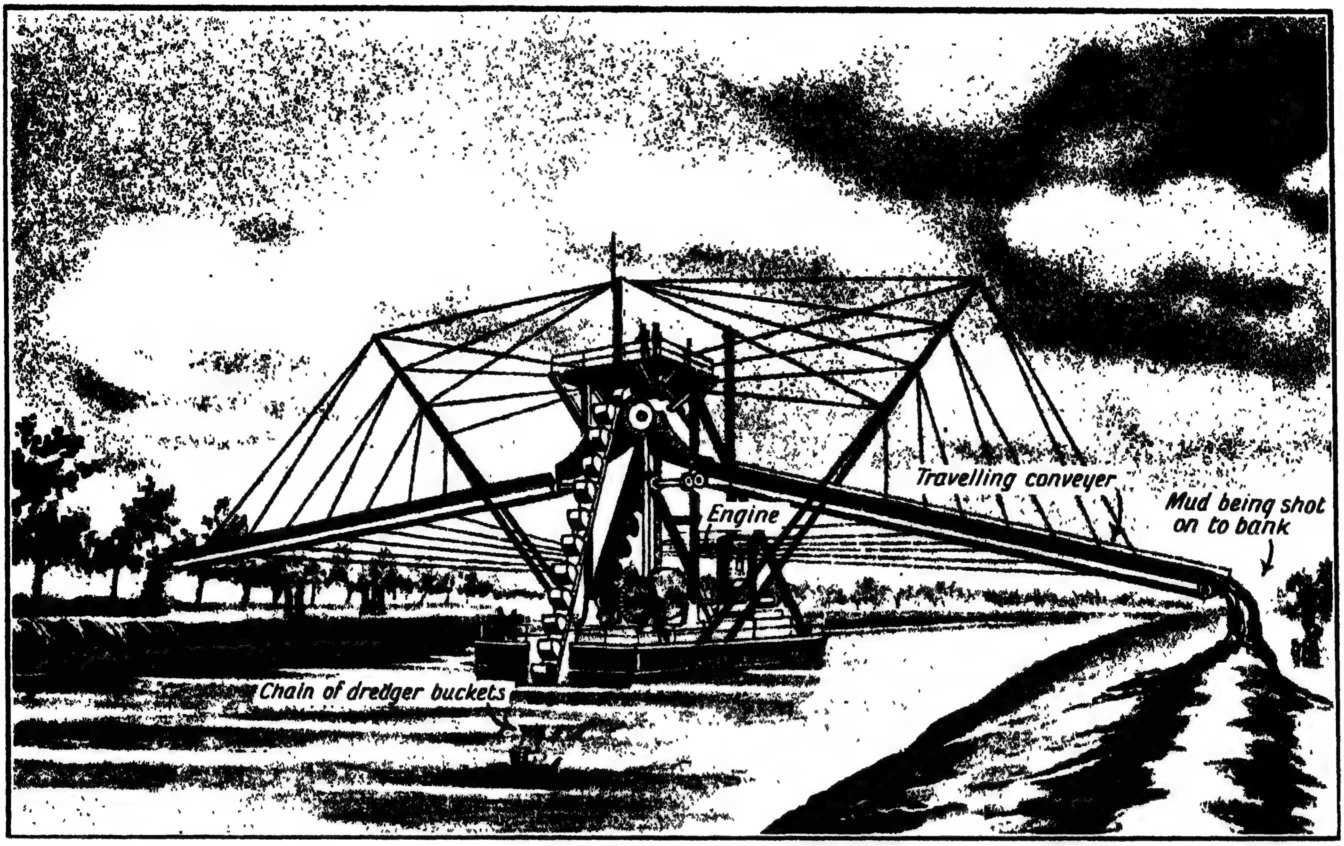
This shows the mechanism all still at 8 minutes to the hour

Striking mechanism preparing to work, at 7 minutes to the hour

Clock actually striking

The power is supplied by weights. The time weight pulls on a drum, forcing it to turn, but an escapement prevents it moving too quickly. The top of the pendulum moves in a fork fixed to the escapement shaft. As the fork goes to and fro it makes the escapement see-saw, releasing one tooth of the escape wheel below at each rise and fall. By means of toothed wheels the clock hands are moved by the escape wheel shaft. The right-hand picture shows how the minute hand shaft revolves inside the hour hand shaft, and by means of gearing both hands move at the right pace. A date wheel is turned one tooth every 24 hours by a pin on a toothed wheel. The pictures on the left show the striking mechanism. A pin on the upper of two minute wheels, as it goes round, meets a pivoted lever. At 7 minutes to each hour it pushes the lever raising the upper arm, on which rests a rack stop arm. A tooth on this is lifted out of the rack, and the rack flies to the left, moved by a spring. The rack moves back a certain number of teeth regulated by a snail wheel, which moves round on the hour hand shaft. The snail lever allows the rack to go back only so many teeth corresponding to the hour. In moving left, the rack releases a catch, enabling the wheels of the striking mechanism to move round, bringing the catch on the warning wheel against a lever extension on the pivoted lever. All is now ready for striking, and at the hour the pin on the minute wheel releases the lever arm and extension, and the striking wheels can then be worked by the drum and weight. Pin projections on the striking wheel lift a bell lever and a hammer hits the bell. At each strike a gathering pallet pushes back the rack one tooth, and at the last tooth the rack is in its original position, a pin stopping the striking mechanism. A fly acting like an engine fly-wheel gives even motion to the striking wheels

HOW A DREDGER DEEPENS THE BED OF A CANAL



After a canal has been dug and the water admitted the bed of the channel often has to be dredged to prevent it from silting up and making the waterway too shallow for ships to pass. This picture shows a remarkable type of dredger which was used in some parts during the making of the Panama Canal. An endless chain of buckets brought up the material from the bed of the canal and carried it to the top of a staging on a floating platform. Here the buckets were emptied into conduits, through which a stream of water was kept running, and so the material was carried to the banks and deposited there, without the time and expense needed for loading it into lighters and emptying it ashore. Of course many other devices, some of them of extreme ingenuity, were used in the making of the Panama Canal, the course of which passes through very varied territory At one place a vast quantity of rock had to be excavated

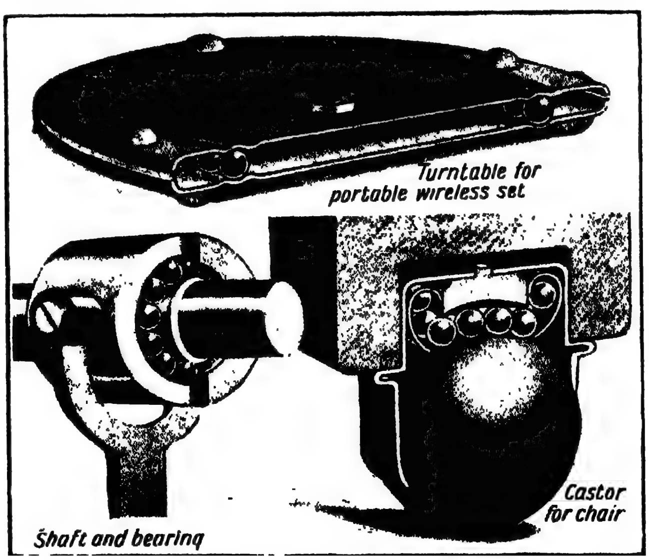
WAYS IN WHICH BALL BEARINGS ARE USED IN THE HOME

THE importance of conquering friction as far as possible in the moving parts of machinery has already been emphasised on page 202, where something was said about the value of ball bearings

This device is used not only in actual machines, as in the case of a shaft and bearing, but in various appliances which we have in the home For instance, many of the more expensive easy chairs are placed on castors which are fitted with ball bearings. These make them move smoothly and easily. Instead of a wheel, the legs of the chair terminate in a large smooth ball which can thus turn in any direction without effort, and where it is actually in contact, ball bearings facilitate the turning as shown in the picture on this page.

Another familiar example of the use of ball bearings in the home is seen in the turntables on which we place our portable wireless sets. These are very ingenious devices, and consist of two metal discs fitted with rubber projections which act as feet for the under disc, and in the upper disc serve as supports for the wireless set The purpose in having them of rubber is to cause friction and so prevent the turntable from shifting its position.

But between the two discs is a complete circle of ball bearings, fitted in a double race groove. It is these that form the points of support between the lower and the upper discs, and when the heavy wireless set rests on the upper disc it can be turned in a moment in any direction with the greatest ease, because the rubber knobs prevent the set from sliding independently of the upper disc, while this disc with the set on top will move round smoothly in any direction, because the polished ball bearings reduce the rolling friction between the upper and the lower discs to a minimum The turntable is an interesting example of a device in which friction is both sought and eliminated



Different examples of the use of ball bearings

Ball bearings are now used in enormous quantities and they are made in standard sizes They are of very high grade steel, which is specially hardened to prevent wear, and the channels or races in which they move are also generally of this hard steel, finished with a high polish.

The ball bearings have to be made with the greatest skill and accuracy, for any deviation from a pure sphere would add to the friction and reduce the efficiency of the bearings

FIRST TO REACH THE PEAK OF EVEREST

After many gallant failures Mount Everest was conquered on May 29, 1953, when the New Zealand climber Edmund Hillary and the Sherpa guide Tensing Nockay reached the summit of the world's highest mountain. The photograph on the left was taken by Hillary on top of Everest, and shows Tensing in the moment of victory holding aloft his ice-axe from which flutter the Union Jack and the flags of Nepal, India, and the United Nations. The dotted line on the lower photograph of Everest indicates the route taken by the climbers

Since 1921, seventy years after Mount Everest had been discovered to be the world's highest mountain, ten other expeditions, seven of them British, had attempted the climb, but all ended in failure. During the 1924 expedition George Leigh Mallory and Andrew Irvine set off on a final assault but were never seen again. It is believed that they came within 1,000 feet of the summit.

The expedition of 1953 which finally defeated the mountain was led by Colonel John Hunt and was organised by the Royal Geographical Society and the Alpine Club. Edmund Hillary and Colonel Hunt were knighted for their achievement. News of it reached the people of Britain, appropriately, on Queen Elizabeth II's coronation day.

THE DANDELION'S WONDERFUL LIFE STORY

The dandelion is perhaps our commonest flower, but it is one of the most interesting to study. On this page we see its life story. The plant produces buds which open into full flower-heads, but, as in the case of the daisy, what we call the flower is really a collection of flowers. If we take hold of one of the yellow ribbons and pull it from the head we shall have a floret or single flower, and each floret can produce a seed. After a time the flowers change to seeds, the seed-head opens and we have the fluffy globe which children like to blow. Each seed has a little parachute which enables it to fall on the ground the right way up so as to penetrate the soil. The leaves, when growing in short grass, lie flat to get the maximum of sunshine, but when the grass is tall the leaves grow upright

THE ROMANTIC STORY OF THE DANDELION

There is no more romantic flower than the dandelion, although it is so common as to be almost despised. In these pages we learn something of the wonderful life story of a plant that in its seed form always interests boys and girls. Indeed children in their play with the seed-head are often agents in spreading the plant

It is doubtful if there is a more familiar wild flower than the common dandelion. It is known almost better than the buttercup or the daisy, and if it were a difficult flower to grow and a root of it cost a great deal of money, it would be very highly prized, and its beauties extolled by enthusiastic ladies and even poets.

But it is such a common flower that only children take notice of it, except those people who find it growing on their lawns. They get very angry with the dandelion, and do their best to root it up, but somehow the dandelion is a very persistent flower, and it is not easy to get rid of it.

Its root goes a long way down into the ground, and its leaves have a wonderful way of adapting themselves to the surroundings in which they grow. When, for instance, a dandelion is growing on a lawn that is kept nicely cut, with very short grass, it spreads its leaves out in a rosette and presses them closely to the soil, so that it is not easy for the gardener to get at them. On the other hand, when the dandelion grows in long grass the leaves grow up almost vertically so as to get their fair share of sunlight and air and dew.

The Lion's Tooth Leaf

If we tear away all the leaves, pull off the stalk and flower-head and even try to dig up the plant, we generally find after a short time that the dandelion is still there; its root reached so far down that it drew nourishment from the soil and soon put out a fresh rosette of leaves and a fresh stalk and flower.

The dandelion is really a very interesting flower to study. We notice that the leaves are lobed and indented; in fact, the flower is called the dandelion because the projections on its leaves are like a "dent de lion," or lion's tooth.

When the leaves spread out as a rosette on the lawn or bare ground these fit together almost like a jig-saw puzzle, with very little overlapping, so that practically the entire surface of the leaves gets the whole benefit of the air and sunshine. When rain falls on the leaves the water runs down the mid-rib so that it soon reaches the earth and percolates through to the tap-root.

The plant has practically no stem, for the leaf stalks and flower stalks spring from where the root ends The stalk on which the flower grows is smooth and hollow, and if we cut it, a milky juice comes out, which is bitter to the taste. This is really the plant's protection against being eaten by grazing animals.

If the tap-root is damaged by being cut across, as with a shovel, a healing tissue which is known as callus, and is a kind of cork, forms to protect the root, and from this new shoots spring up.

The flower of the dandelion is well worth study, and we should gather one and examine it. What we call the flower is not really one flower, but a large number gathered to form one flower-head. There are anything from 100 to 300 flowers on the one head.

Children play "One o'clock, two o'clock" with the seed-heads of the dandelion, but they little realise when they do this what a wonderful plant the dandelion really is

The flowers have no stalks, and they are crowded on the flat, circular top of the flowering stem or axis. Each flower, that is, each of the little yellow florets, is inserted in a small pit.

Let us pluck from the flower head one full-grown mature flower, and examine it through a lens. We pluck it by the narrow, yellow, ribbon-like growth, and we find that there are many parts to the flower.

The little style or stalk of the flower is divided at the top into two curled branches, with short hairs on the inner surface. These form that part of the female flower which receives the pollen from a male flower, enabling the plant to produce seed. Right at the base of the flower is a little swelling, which is the ovary, where the actual seed is produced. Above it are some little hairs, and when the seed is actually formed these hairs develop into a parachute, which enables the seed to sail through the air and alight safely on the ground in the right position for the seed to enter the soil.

Just as there are more than a hundred flowers round the top of the stem when the dandelion is in blossom, so there are now anything from 100 to 300 seeds, each fitted with its little parachute, gathered in a globe at the top of the stalk.

Free Salad and Coffee

Children love to take these and blow them, professing to tell the time by the number of puffs it takes to remove all the seeds from the dandelion stalk. Children also often take the stalks, which are hollow, and use them for blowing soap bubbles, or sucking water up from a spring, or for blowing through to produce queer noises.

The dandelion is a useful plant, for the young leaves when gathered make an excellent addition to a salad, and the root, when ground and roasted, makes a good substitute for coffee.

The dandelion is almost an evergreen plant, and it can be found flowering in every month of the year.

But now we come to the most interesting thing about the dandelion. As we know, to produce seed and carry on the race it is the general rule that the female flowering plant must be fertilised with pollen from a male flower, and this production of pollen and fertilisation of the female flower does take place in the dandelion.

But the strange thing is that if the dandelion, for any reason, is not fertilised, it still produces seeds, which means that the mother dandelion can have offspring even when there is no father. We find this kind of thing among some of the lower forms of animal life, but it is rare among flowering plants. There are some, however, which follow the strange custom, and of these the dandelion is the most common and familiar.

The discovery that the female dande-

lion flower is able to produce seed without being fertilised with pollen has only been made during the last few years. A botanist, making experiments, removed the pollen-bearing and pollen-receiving organs of dandelions before they were mature, and left the plants growing in a special position. Strangely enough the seeds were produced, just as though the flowers had been fertilised in the ordinary way.

The curious thing is that the dandelion should go on producing pollen when it does not need it. Nature does not usually produce anything that is unnecessary.

It is not customary in England to cultivate the dandelion, but in France the plant is grown by market gardeners round about Paris in order to supply the markets with the fresh young leaves for salads. There was such a demand for the wild leaves that the enterprising gardeners began to grow the dandelion as a pot-herb and by selecting the best seeds they soon improved the species.

GRASS THAT GROWS AS TALL AS A CHURCH SPIRE

We may have seen some very tall grass growing in English fields, and little children hiding in it so that they cannot be seen from a distance But we do not usually think of grass growing as tall as a church spire, nor as thick round as a tree trunk, nor as hard as a brick.

Yet there are in Eastern countries, like China and Japan and Malaya and the East Indies, grasses that grow to this enormous size. The grass is called bamboo, the name by which the natives know it.

Like our own grasses, bamboo springs from an underground root stock, and the stems grow as closely together as do the blades of grass in our fields and lawns. Often the stems rise to a height of 120 feet, and they are as big round as the trunk of a birch tree When standing in a bamboo grove it is difficult to think of these giant plants as being merely grasses So closely together do the stems grow that it is often quite impossible to pass through a bamboo plantation.

The growth is amazingly rapid Bamboos have been carefully watched, and have been found to grow as much as 16 inches in a single day In fact, it is often said, and it is almost literally true, that you can stand and see the bamboo grow

Grass as Food and Shelter

In China, although the bamboo grows wild, it is also cultivated as carefully as any other useful plant, and it is employed for very many purposes The young shoots and the seeds are used as food, while the hard, woody stems are used for building houses and making furniture and vehicles and agricultural implements. The stems also serve as masts for small sailing-boats, and the fibrous material is used in making the walls of native houses, mats, screens, baskets, utensils, hats, capes and ropes. The fibre is also used for the wicks of candles.

Marco Polo, the famous traveller of the Middle Ages, was familiar with bamboo, and he tells us how he saw the people of the East split long canes of bamboo, 30 feet in length, and from the thin pieces twisted together make ropes as long as 600 feet, which were used for towing boats on the rivers and canals and for other purposes.

Another early traveller describes how these ropes were made in China, the natives mounting scaffolds 12 or 15 feet high and letting the cord fall to the ground as it was plaited. Bamboo rope is exceedingly good, for it is not only strong, but very light, and can be used in circumstances where hempen cord would be too heavy

The sails of Chinese junks, as well as the cables and rigging, are often made of bamboo. An old Venetian traveller tells us that during a visit to the East he saw a prince's palace, the roof of which was made of bamboo canes, richly covered with gilt and varnished Each of the canes, he says, was three palms in circumference and 10 fathoms long, and being cut at the joints, was split into two equal parts and laid alternately concave and convex to form gutters.

A bamboo grove in the province of Che-kiang, China, where the giant grass grows to a height of over a hundred feet

In recent years bamboo has been greatly used in Europe and America for the making of cheap furniture, such as tables, chairs and bookcases. But, of course, it looks less appropriate in Western houses than it does in the East.

The Chinese make paper from bamboo by hand processes, but though the plant is fibrous, no method has yet been found of utilising the fibre for the manufacture of paper by modern mechanical methods. If somebody could find a way of doing this cheaply and producing a really tough paper, the whole paper industry of the world would be revolutionised. It would be a great boon to the world to discover some way of making good serviceable paper from bamboo fibre.

One of the problems that has faced the world in recent years is the possibility of a paper famine. The paper we use now for our newspapers and books is made from the timber of trees that take many years to grow But bamboo, because of its very rapid growth, would be the most useful of all plants for the purpose.

Whetstones Made of Bamboo

While looking like tree trunks, the bamboo stems are quite different in structure. They are hollow, like great tubes, and the outsides are coated with a deposit of flint, so that the woody bamboo is hard to cut and the edge of a knife used upon it is soon blunted. It is the mineral matter in the bamboo that turns the edge of the knife. So flinty, indeed, is this, that the bamboo is often used in China as a whetstone.

The seeds of these giant grasses vary a good deal in character. In some species of bamboo they are like a big nut, while in others they are large and fleshy, something like an apple.

Like other grasses, the bamboo has joints all the way up its length, and at each joint there is a partition or diaphragm across the stem. The natives of China and Japan are very fond of making ornaments and utensils out of the thick, hollow tubes. Umbrella stands, vases and so on, of carved bamboo are quite familiar objects in Eastern houses. The difficulty with the material is that when it becomes dry it often splits. The hard, woody divisions at the joints enable the bamboo to be made into receptacles such as flower vases.

Like our English grasses, the bamboo bears flowers in bunches. Some species bloom every year, while others go several years without any blossom. Of all the higher types of plants the bamboo is the most rapid in growth.

When bows and arrows were used the people of the East used bamboo very largely for their bows. They have also used the bamboo canes as pipes for conveying water.

THE WORK OF DIFFERENT PARTS OF THE BRAIN

The human brain is a very complex piece of machinery, and different parts of it are used for different purposes. Our nerves carry messages to the brain from different parts of the body, and messages are sent from the brain to eye, ear, arm, leg, and other organs, telling them what to do. But the nerves for the different functions lead to different parts of the brain. For example, the front of the brain deals with speech, whereas the back deals with seeing. When a well-known footballer fell on the field during a game and was kicked by accident on the back of his head, he was blind for several days. The reason can be seen quite clearly from this picture, for it was the seeing part of his brain that was damaged and so upset his sight for the time being

THE WONDER OF THE BEAUTIFUL CAMEO SHELL

From ancient times cameos have always been regarded as art treasures of great value. A cameo is a precious stone which is so carved that the design, whether it be a portrait or some other figure, stands up in relief above the background It is the opposite of what is known as an intaglio, in which the design is cut into the stone and is, therefore, lower than the main face of the gem. The word intaglio comes from the Italian, and means "cut into," but nobody knows the origin of the word cameo.

Beauty from a Strange Source

Now while in ancient times there were many cameos made of precious stones of all kinds, a new kind of cameo has been made in modern times, and the modern cameo is carved not on a precious stone, but on a shell.

In the days of Queen Victoria shell cameos were made into rings and brooches and were largely worn. They are not worn to-day, but we often see them in the windows of curio shops, and many people collect them Not many, however, know when they see one of these brooch cameos that the material that provides the beautiful relief work is from the shell of a mollusc, which is a relative of our snails and slugs

There are several kinds of shells used for the cutting of cameos, but the best is known as the Bull's Mouth shell because of a fancied resemblance between the pointed end of the shell and the mouth of a bull. Scientists call this mollusc Cassis rufa, a name which means red helmet. It is quite a good name, for the shell is shaped very much like a helmet and the outside of it is red

When we look at one of these shells six inches or so long and nearly as broad, it seems wonderful to think that a soft-bodied creature like a snail can have built up the shell from materials which it finds in the sea water.

Layers of Colour

The cameo shells are found in the sea in both the East and West Indies, and round about Madagascar, and they are not of the same material throughout. It is because there are layers of different colours that the shells are so much sought after for the cutting of cameos.

Some of them are really extremely beautiful and classical figures are carved so as to stand out in pure white on a brown or fawn background. It would be interesting to know who was the clever man who first discovered that he could make a cameo out of a mollusc's shell. The finest cameos made from precious stones are carved on gems like agate that consist of layers of mineral of different colours, and perhaps that gave the idea to the first shell cameo cutter.

On this page is shown an example of a cameo brooch with the Three Graces carved on part of a shell, and the whole cameo is mounted in a gold circlet.

A beautiful specimen of a cameo brooch

A cameo carved on the shell of a mollusc related to our snails and slugs. It is from these shells that cameo brooches are made

But more interesting is the lower picture which shows a cameo actually carved on the shell itself, and remaining on the shell.

At the time when cameo brooches, rings and pendants were fashionable, the carving of the designs on the shells was quite a big industry, especially in the south of Europe, where many artists earned a good living producing what can quite justifiably be called works of art. Now, however, far fewer shell cameos are wanted.

Shell Trumpets of the Ancients

The cameo shells belong to that branch of the great mollusc family which is known as the gastropods. There are many branches of the family, one being the snails and slugs, another the limpets, another the whelks, another the periwinkles.

A branch of the family to which the cameo shells belong includes the tritons, those large and strong marine shells found in the Pacific often a foot or more in length. The triton shells of the Mediterranean, a different species from their Pacific relatives, were used by the Ancient Romans, as trumpets. We often see pictures of the ancient gods blowing large triton shells.

The cuttle-fish, the squid, and the octopus and also the pearly nautilus, are also molluscs, and are related to the cameo shell mollusc. The name mollusc, which means soft, was first given to the cuttle-fishes only, and then later on was extended to all the other members of the family.

The chief feature of the members of the gastropod family is the possession of what is known as a foot. "Pod" means a foot. Of course, it is not a foot in the same sense as our own or that of birds and mammals. What is called a foot in a gastropod is a muscular expansion on the underside of the body, and it is by means of this that the creature is able to crawl over some firm substance like the ground or a rock.

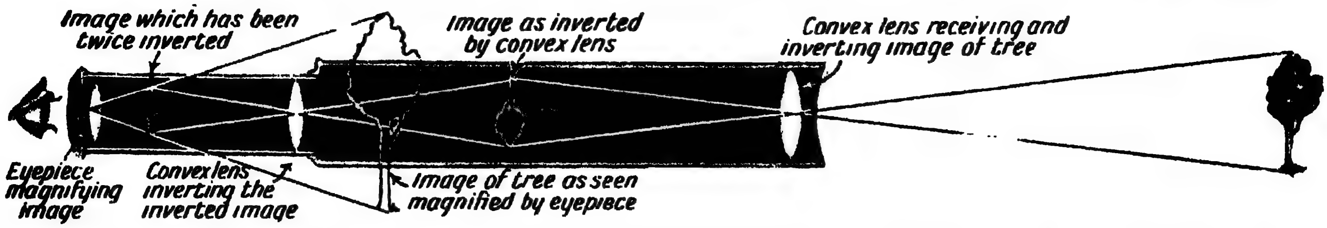
A Marvel of Nature

How strange it seems that a creature of this kind can produce a shell so constructed that with it a man can make a beautiful work of art. Yet the man who is so clever in this way cannot possibly do what the mollusc does, namely, make the shell from materials dissolved in the sea. It is one of the greatest marvels of nature that these soft creatures that live in the sea can extract from the water the mineral matter and build up shells for their homes of a vast variety of shapes and sizes.

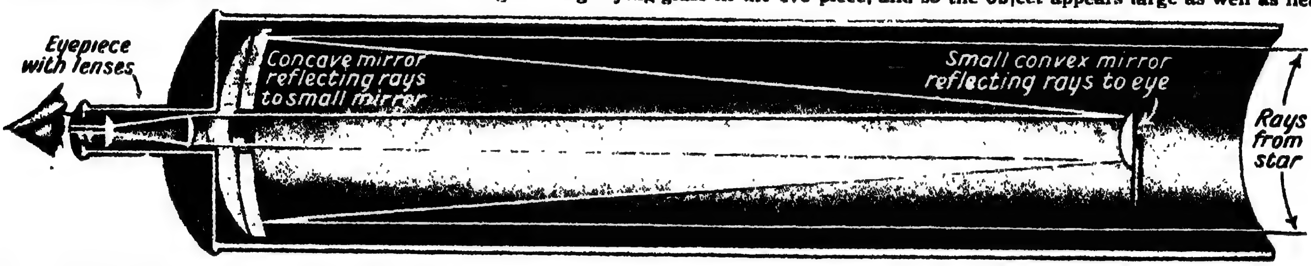
THE LYNX-EYED CARACAL GETS ANGRY

The caracal shown in this picture is an animal midway between the wild cats and the lynxes. It is larger than the wild cat but smaller than the true lynxes, and in colour is reddish-brown, the under parts being paler. Its most noticeable feature is the long ear, tufted with black hair. The eyes are very bright, and the common expression "lynx-eyed" is believed to owe its origin to this species and not to the true lynxes. The caracal is a rather rare animal, and is found in Asia and Africa. It is a creature of the grass and bushes rather than the forests, and its food consists of gazelles, small deer, hares, and birds like the crane and pea-fowl. It is said to be able to spring up and capture a bird on the wing at a height of six feet. The caracal can be easily tamed and has often been made a pet

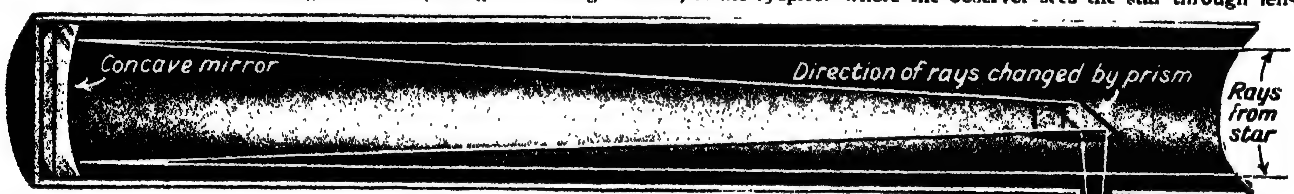
HOW A TELESCOPE BRINGS THINGS NEAR



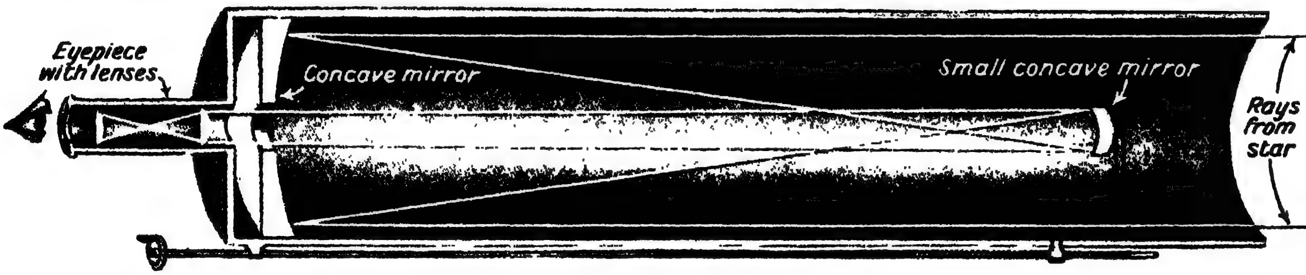
This picture-diagram shows an ordinary telescope for looking at objects on the Earth. It is known as a terrestrial telescope, from the Latin word terra, meaning the Earth. It differs from the astronomical telescopes shown below in producing images in their true position and not upside down This result is brought about by using an extra convex lens. Rays of light pass from the object to be viewed to a convex lens known as the object glass, which corresponds to the object glass of a microscope as shown on page 23. This curved lens causes the rays to be bent at an angle, and to cross one another, forming an inverted image of the object at a certain point in the telescope tube. This inverted image is once more inverted by the convex lens first referred to, so that an image the right way up is formed near the eye-piece. The distant object seen is thus brought near to the eye and appears as if it is only a short distance away. In order that it may be seen better, it is viewed through a magnifying glass in the eye-piece, and so the object appears large as well as near



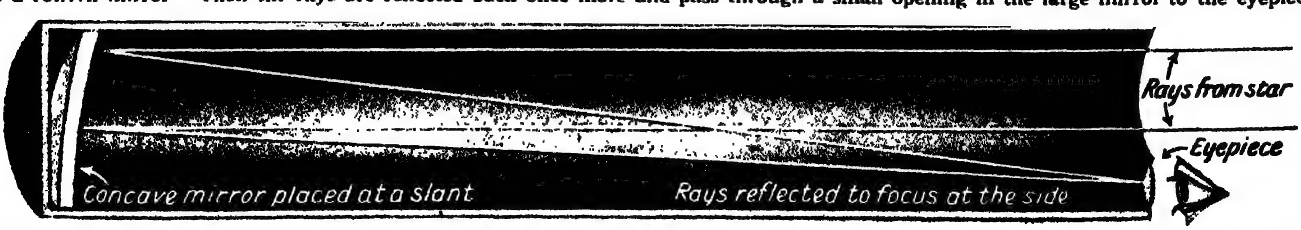
The earliest telescopes used by astronomers were like the terrestrial instrument shown above, except that there was no extra lens to show the object right way up. The largest astronomical telescopes, however, are of a different type known as reflecting telescopes, because the image of the star or other object is caught by a big mirror and reflected back to another mirror or prism. The type shown here is called the Cassegrainian telescope, after its French inventor Cassegrain, who lived in the 17th century The rays from the star are caught by a large concave mirror near the eyepiece and reflected back to a small convex mirror at the other end of the telescope. This, in turn, reflects them back, through a small opening in the large mirror, to the eyepiece where the observer sees the star through lenses



This is the Newtonian telescope invented by Sir Isaac Newton. Here the rays from the star or other object are caught by a large concave mirror at the end of the telescope and reflected back to a small right-angled prism placed in the position shown. The light rays enter the prism and are reflected by the slanting face, so that they enter the eyepiece almost at right angles. The eyepiece in this telescope is in the side of the tube



In this picture-diagram we have the oldest type of reflecting telescope invented by James Gregory, a Scottish mathematician, in 1663, and called after him the Gregorian telescope. Gregory was the actual inventor of the first reflecting telescope. It is very much like the Cassegrainian telescope shown above, except that the image is reflected from the large concave mirror to a small concave mirror instead of to a convex mirror Then the rays are reflected back once more and pass through a small opening in the large mirror to the eyepiece



Finally, we have here the Herschelian reflecting telescope invented by Sir William Herschel. In this instrument the concave mirror is slightly tipped so that the image of the star, instead of being formed in the centre of the tube, is formed near one side of it, and the observer thus looks directly towards the big mirror. It is the simplest type of reflecting telescope and involves the least loss of light, but the slant of the mirror causes some distortion of the image viewed, and for this reason the Herschelian type is now entirely abandoned

THE ROMANCE OF THE TELESCOPE

The invention of the telescope is one of the greatest romances of science, for it is this instrument that has revealed to us the marvels of the universe in which we live and move and have our being. Without it we could never have known anything about the nature of the countless suns and worlds that are dotted throughout space; they would have remained for all time merely twinkling points of light. Here is the story of the telescope and its invention in the early years of the seventeenth century

Who made the first telescope? No one can say, for its inventor is not known definitely, although there seems little doubt that Holland can claim the honour of being the country that gave this wonderful and valuable instrument to the world.

There is a story that it was a spectacle-maker's children playing with lenses who first made the great discovery that by means of convex glasses distant objects could be brought near. They were the children of Zacharias Jansen, a tradesman of Middelburg, and were one day holding up the lenses to look at various objects through them when suddenly one of them cried out excitedly that the weathercock of the church had come nearer.

His father, hearing the cry, came out of the shop and found that it was a fact that by arranging the lenses in front of one another he could bring the vane on the church spire much nearer to the eye than it actually was. He fixed the lenses to a board for steadiness and is said to have thus made the first telescope.

The Moving Church Spire

The honour of inventing the telescope is, however, claimed for another Dutchman, also a spectacle-maker of Middelburg, one Hans Lippershey, and he, too, is said to have obtained the idea accidentally by bringing the church spire nearer when holding up lenses to look through them. A third claimant for the invention of the telescope is James Metius, of Alkmaar. But whichever was the true inventor there is no doubt that it was in Holland that the first telescope was made.

When in 1608 Lippershey applied to the States-General of Holland to grant him a patent for the telescope, this was refused on the ground that the invention was already known, but the States-General ordered one or more instruments from him and commanded him to keep the construction a secret, as Holland was then at war and it was hoped to reap great advantages from an instrument that would bring the enemy's fortifications and operations near to view.

However, telescopes began to find their way to Paris and other towns in Northern Europe, and Galileo, the great Italian astronomer, having heard about them and being unable to secure one, set about re-inventing the instrument, and made several telescopes which opened the wonders of the heavens to him. He is really the hero of the telescope, for he it was who improved the instrument beyond all recognition, so that it was able to reveal marvels that had never been dreamed of before.

Among the first of the discoveries which Galileo made with his telescopes was the fact that the Sun has spots on its face. Then he found that the planet Venus has phases like the Moon, that is that it is sometimes a disc and sometimes a crescent. Next he discovered four of the moons of Jupiter, and then the rings of Saturn, although he did not know that they were rings; he thought they were satellites, one on each side of the planet as shown on page 85.

Galileo's best telescope magnified only about thirty times and the making of lenses in his day was so imperfect, that his telescope was far inferior to a telescope with only the same power made to-day.

The principle on which these early telescopes were made can be seen in the first picture on the opposite page. It is a refracting telescope, but there is one difference, and that is that an extra lens has been put in so that the object viewed can be seen the right way up.

This is necessary for the telescopes used by seamen and others, which are to bring near ships and other objects on the earth itself. If these were seen upside down it would be very inconvenient, but when we are looking at the Moon and planets and other objects in the sky, it does not matter that they are seen inverted, and so the extra lens is left out of astronomical telescopes.

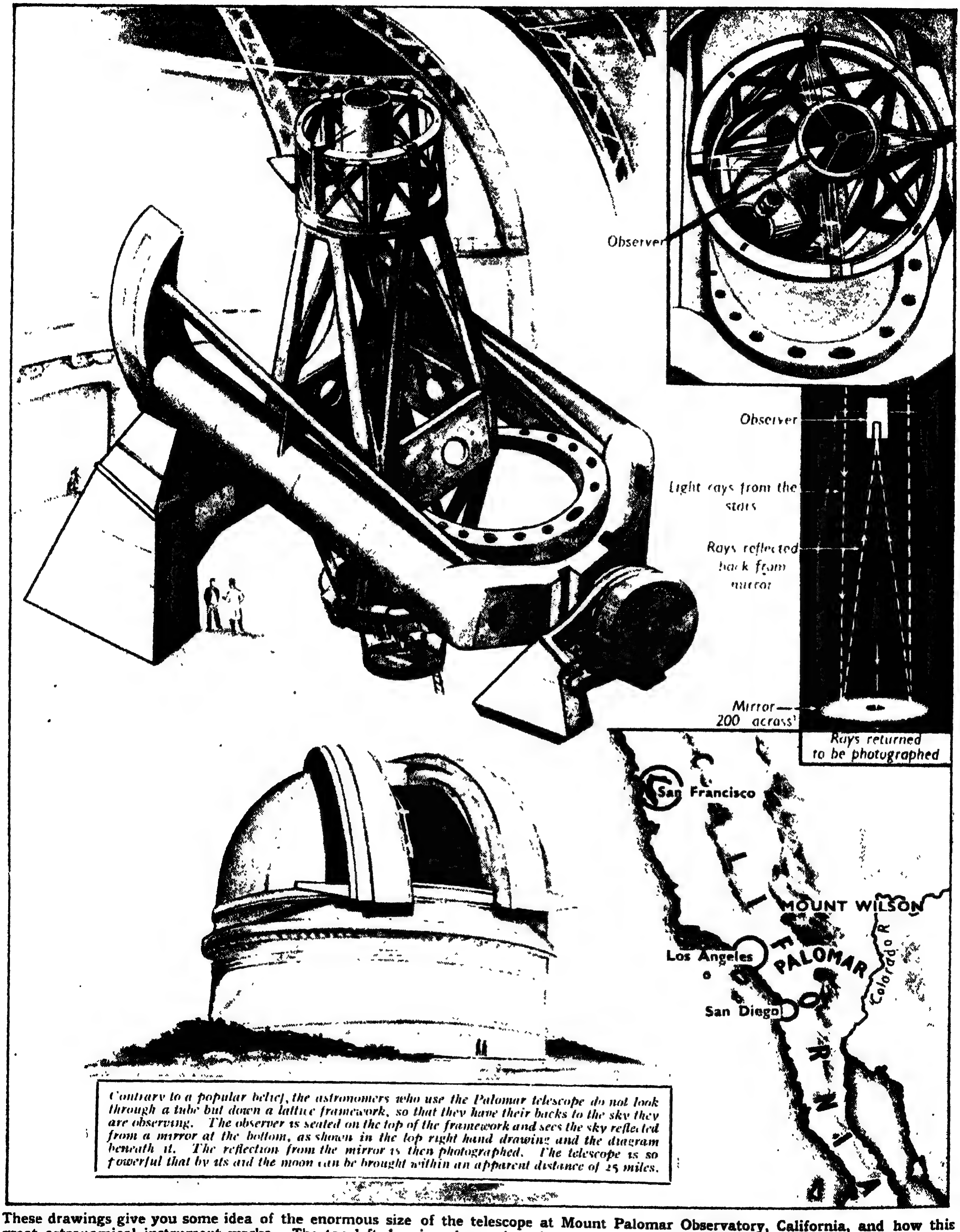
Two Kinds of Telescope

The big lens at the end of the telescope brings the object near and focuses an image of it in the tube, and then the image is magnified by another lens in the eyepiece. This kind of telescope is called a refracting telescope because the rays of light are refracted or deflected by the lens.

There is another kind of telescope, however, and that is known as a reflecting telescope, because the object viewed is not looked at directly but is first caught by a large mirror and then reflected back by another lens or a prism to the eyepiece. There are different forms of reflecting telescope, invented by different astronomers like Newton, and Herschel, and these are shown and explained on the opposite page. Another kind of telescope is the radio telescope described elsewhere in this book.

How a Dutch spectacle-maker's children are said to have invented the telescope by holding two convex lenses in front of one another, thereby making the weathercock on the church look much nearer

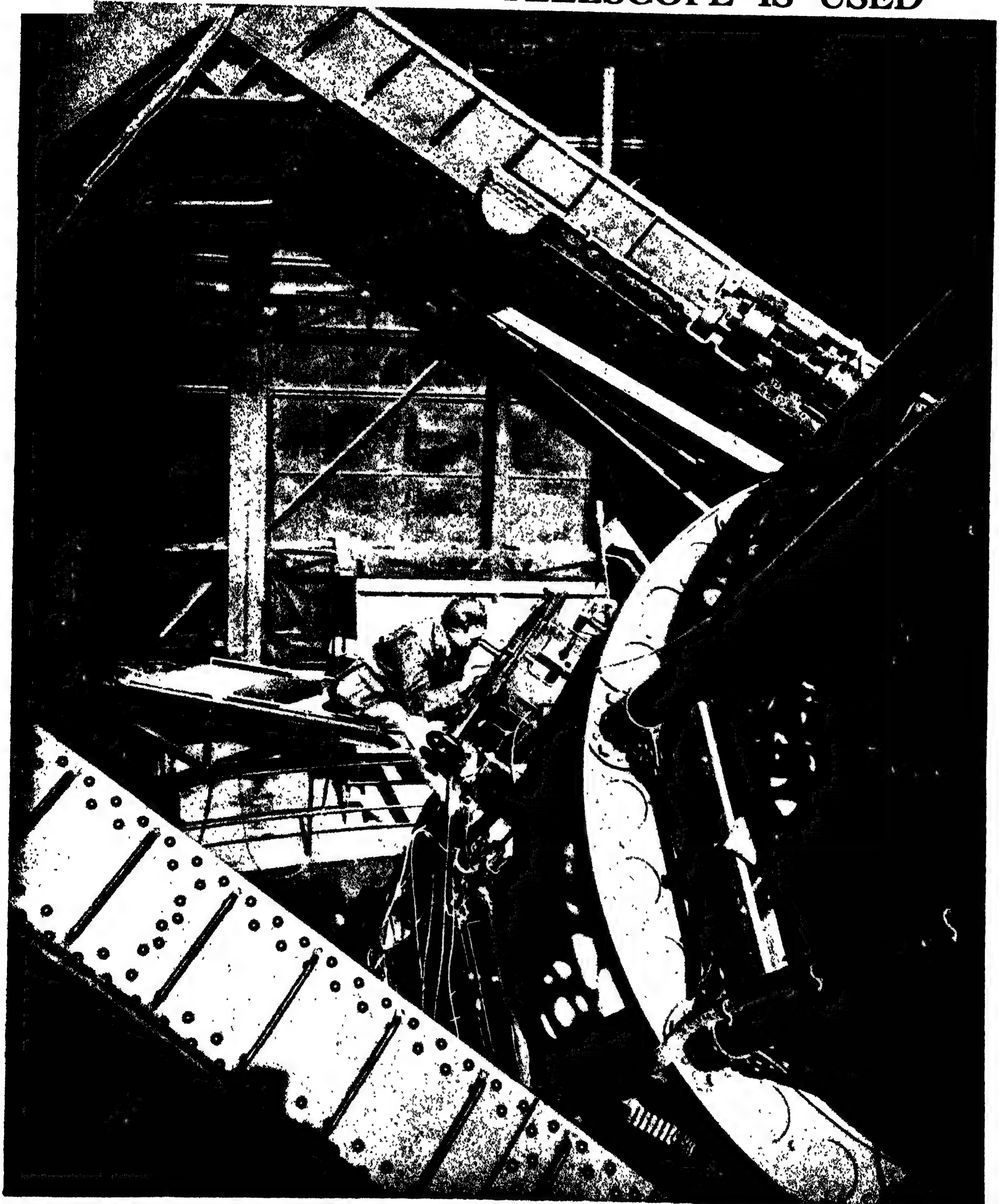
INSIDE THE WORLD'S BIGGEST TELESCOPE



Contrary to a popular belief, the astronomers who use the Palomar telescope do not look through a tube but down a lattice framework, so that they have their backs to the sky they are observing. The observer is seated on the top of the framework and sees the sky reflected from a mirror at the bottom, as shown in the top right hand drawing and the diagram beneath it. The reflection from the mirror is then photographed. The telescope is so powerful that by its aid the moon can be brought within an apparent distance of 25 miles.

These drawings give you some idea of the enormous size of the telescope at Mount Palomar Observatory, California, and how this great astronomical instrument works. The top left drawing shows the telescope on the counterweighted mounting that enables it to point to any part of the sky, and the bottom drawing shows the building in which it is housed. **See also photographs on page 1130.**

HOW THE GIANT TELESCOPE IS USED



In this photograph we see an astronomer at work with the great 100-inch reflecting telescope at Mount Wilson Observatory. The mirror is 13 inches thick, that great thickness being necessary to prevent the mirror from bending under its own weight. The preparation of the huge mirror, which took ten years, was well worth while, for the 100-inch telescope has, since its erection, revealed, by means of photography, the presence of over three hundred million new stars. The instrument is housed in a steel building with a hundred-foot dome weighing 500 tons, and this can be revolved by means of electrical appliances as easily as if it were made of cardboard. All the moving parts of the telescope are also electrically controlled. There is a 200-inch reflecting telescope at Mount Palomar, California

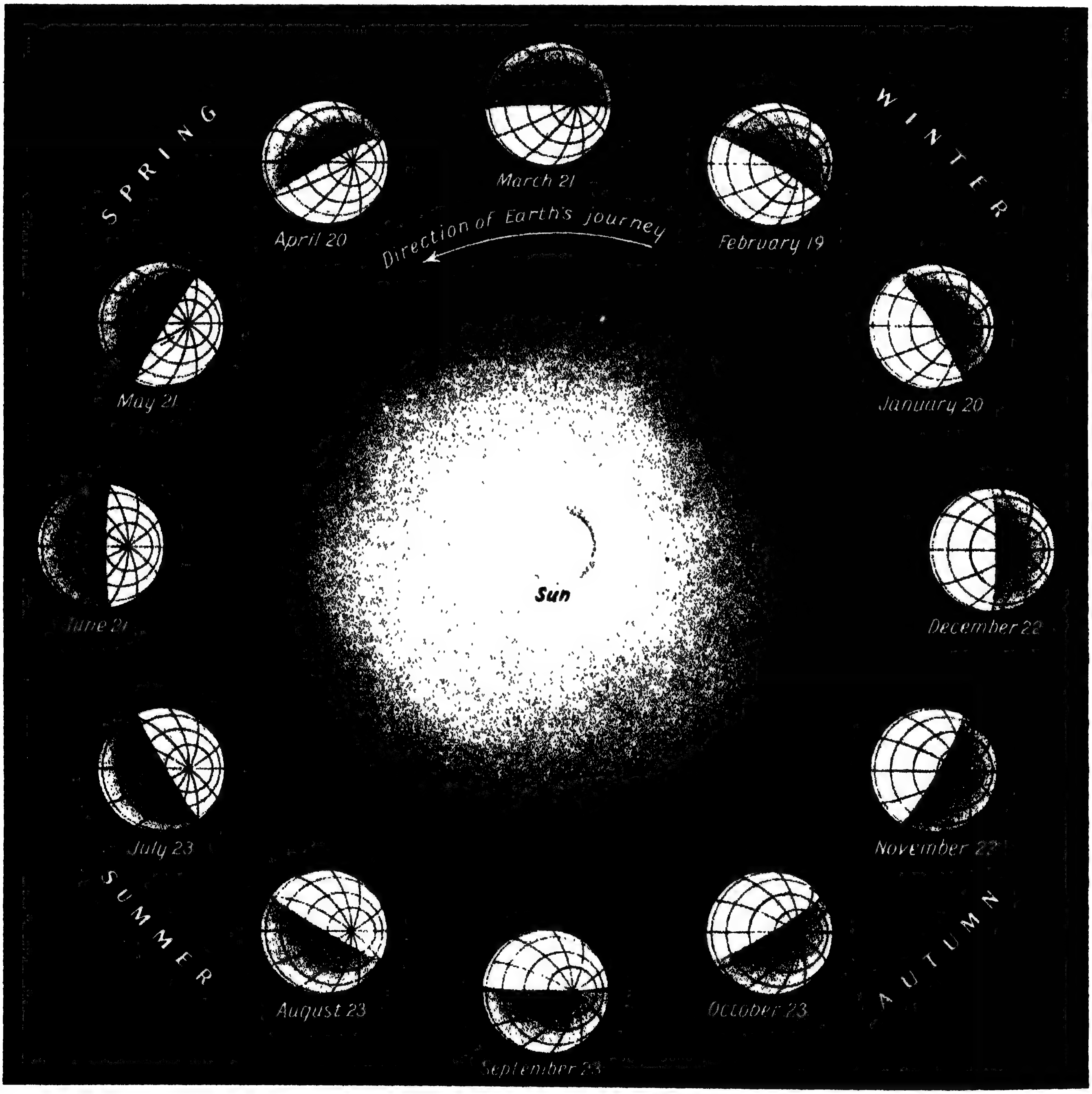
WHY THERE IS A LONG POLAR NIGHT

Many people cannot understand why it is that in the polar regions the Sun is not seen and darkness reigns for about five months of the year, and that the Sun never sets for another five months.

The picture on this page will explain the matter. It is because the Earth is tilted that the polar regions have a night lasting for nearly half the year, and then a day lasting for nearly the other half. If the Earth turned round on its axis in an upright position day and night would be equal all over the world.

In the diagram we are supposed to be looking down upon the North Pole and the Earth, and we see that as the Sun shines upon the Earth half of the sphere is lighted up, but when the tilt is away from the Sun the Sun's rays cannot reach the polar regions. On the other hand, when the tilt of the axis is towards the Sun, then the Sun's rays reach the polar regions for the whole of the 24 hours. The same thing happens round the South Pole, only of course when the long daylight of many months is experienced there, it is the polar night in the north, and vice versa.

We can understand, after studying this picture-diagram, why it is that the Sun can be seen shining in the sky at midnight in far northern regions like the north of Scandinavia as shown in the photograph printed on page 77.



In this picture-diagram we are looking down upon the Earth's northern hemisphere, and we see its position in relation to the Sun for each of the twelve months of the year. Because of the tilt of the Earth, for several months the Sun's rays cannot reach the regions round the North Pole, and similarly when the North Pole is tilted towards the Sun, as in the spring and summer, these regions are never out of the Sun's light, and so there is a long day lasting over several months. Of course the reverse happens round the South Pole, that is, when winter reigns in the north it is summer in the south, and when it is spring in the north it is autumn in the south

THE TILER OF KENT MEETS THE BOY KING

Everyone has heard of Wat Tyler, and knows that he was slain by a Lord Mayor of London. But not many people know the real story of Wat Tyler's rebellion and how it came about. Here we read the stirring narrative, and see how well the brave young king, Richard the Second, began his reign, although years afterwards it ended in miserable disaster

RICHARD THE SECOND was a very different type of man from his father, the Black Prince, and his grandfather, the brave and strong-minded Edward the Third. He was more like his great-grandfather, Edward the Second, and his reign of twenty-two years ended in ruin and disgrace.

Yet he started well. The last few years of Edward the Third's reign had not been happy ones for the country. The old king fell into the hands of bad favourites, the war with France led to oppression and ruinous taxation, and the king's son, John of Gaunt, Duke of Lancaster, with two of his brothers, the Dukes of York and Gloucester, took charge of affairs, and ruled so harshly that the people came to hate them.

Then the old king died, and Richard mounted the throne, while he was only eleven years old. Of course, he was far too young to take the reins of government into his own hands, and so his powerful uncles went on ruling the country in his name.

The New Poll Tax

Everyone was disposed to love the young king for his father's sake, and hoped that he would prove a worthy successor to the great King Edward the Third; and indeed, the first active part the young king took in the conduct of affairs promised very well for the future. Unfortunately, the promise was not fulfilled.

The war with France still went on, and more and more money was needed to maintain the armies abroad. Taxes increased as the people became impoverished, and at last the taxes would not bring in sufficient money to pay for the war. What could be done?

A new tax was invented, known as the poll tax, which meant that there was a tax levied on every head or poll in the kingdom. At first it was not so bad, for, like our own income tax to-day, it was graduated so that people paid according to their means, or, at any rate, their rank and position. The peasants were to pay one groat, or fourpence, barons £2, earls £4 and the Duke of Lancaster, the highest subject in the realm, was to pay £6 13s. 4d. These sums may not seem very great to us to-day, but we must remember that at that time money was worth at least twenty times what it is nowadays. A groat would be equal to about 6s. 8d. and that was a very large sum for a poor labourer to find, seeing that wages were very, very small, as compared with to-day.

The Crushing Burden of Taxation

When the tax was collected there was still not enough to pay for the war, and so in the following year another poll tax was levied, and this time not only was it greatly increased, so that the poorest person had to pay three groats, equal to about £1 of our money, but there was less care in graduating it. Instead of specifying what the people of different ranks were to pay, a general statement was issued that the rich were to help the poor.

In those days the rich had very little regard for the poor, and looked upon them more or less as cattle, useful for doing the world's work, but with no claim on the consideration of those above them. They therefore did very little in the way of helping them with their taxes.

Not only so, but when the money did not come in fast enough, commissioners were sent all over the country to speed up the collection, and to see that people paid. These commissioners were far from being tactful and considerate. They were overbearing, and not only searched the houses, but the persons, of the people, to find out if they were concealing anything of value. In many cases their behaviour especially to women, was extremely rude.

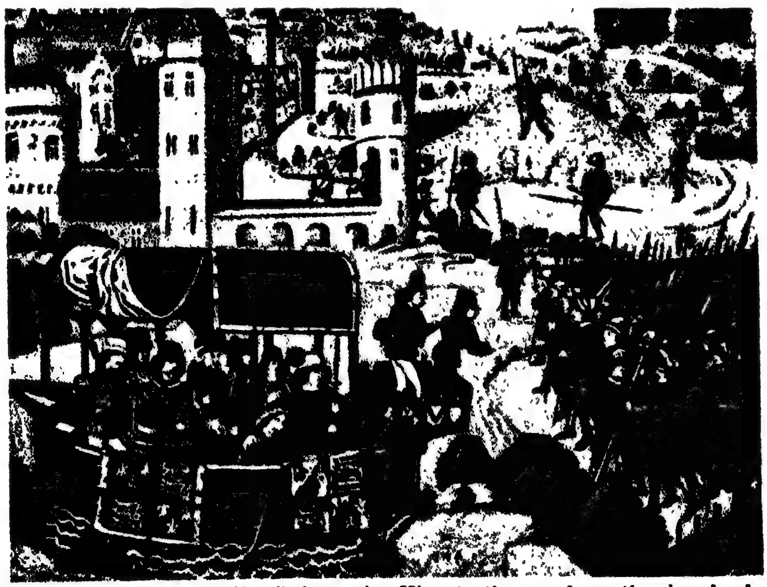
The people all over the country were boiling with rage, and their condition was very much like that of gunpowder, only waiting for a spark to make an explosion.

This spark was applied at Dartford in Kent, where one of the commissioners or tax collectors insulted the daughter of a tiler, that is, a man who tiled roofs of houses. The man's name was Walter, and he was called Wat for short. In those days the common people had no surnames, and so to distinguish this Walter from others he was known as Wat the Tiler. In history he is generally referred to as Wat Tyler

A Tax-Collector's Fate

So angry was he at the treatment of his daughter that, taking up a rod used in his trade, he felled the collector, killing him on the spot.

The townspeople approved this deed, and the news of it spread like wildfire through the countryside. The people flocked in, determined that now at last they would rise against the oppression from which they had been suffering and put an end to it.



"What do you want?" called out the King to the people on the river bank. This picture of King Richard meeting the rebels, is from an old painting

Wat Tyler is said to have taken the lead, but there were various other tilers who joined the crowd, and it is difficult to know which is referred to in the old chronicles. However, the general opinion seems to be that it was Wat of Dartford who took the lead, and he was joined by two other men who took a prominent part. One

was known as Jack Straw, and probably he was a thatcher, while the other was a priest named John Ball. Froissart calls him "a crazy priest," and says that he had been three times sent to prison by the Archbishop of Canterbury for preaching in such a way as to inflame the people.

Every Sunday, after mass, as the people were coming out of church, John Ball, we are told, preached to them in the market place in this way:

"My good friends, things cannot go on well in England, nor ever will, until everything shall be in common: when there shall be neither vassal nor lord, and all distinctions shall be levelled; when the lords shall be no more masters than ourselves. How ill they have used us! And for what reason do they hold us in bondage? Are we not all descended from the same parents, Adam and Eve?"

"And what can they show or what reasons give why they should be more the masters than ourselves, except perhaps in making us labour and work for them to spend? They are clothed in velvets and rich stuffs, ornamented with ermine and other furs, while we are forced to wear poor cloth.

"Let us go to the King, who is young, and remonstrate with him on our servitude, telling him we must have it otherwise, or we shall find a remedy for it ourselves."

It is interesting to note that when times are bad there are always some who preach Communism, and suggest that the goods of the rich shall be divided up among the poor.

John Ball's Text

Of course, if this were done it would make little difference, for all the riches of the well-to-do, if spread out among the mass of the people, would give very little to each. It is a teaching that finds a hearing when people are oppressed, as it did in Russia after the Great War.

Of course, there was a great deal of truth in what John Ball said. His favourite text for these sermons was a rhyme:

"When Adam delved and Eve span,
Who was then a gentleman?"

"Delved," of course, is an old-fashioned word for "dug," and pictures of Adam and Eve working in the Garden used to be painted up on the walls of the churches, so the people would take a good deal of notice of the rhyme.

Of course, when the crowds began to gather the rich were very frightened, and they looked upon the demands of Wat Tyler and John Ball as outrageous. A well-to-do Kentish friend of the poet Chaucer, and himself also a poet, John Gower, wrote about the mob whom he likened to oxen and asses: "Asses, disdaining the curb, rose like wild lions to seek their prey, and leaping about the fields, terrified all the citizens with their wild hee-haw. They would no longer carry sacks into the town, nor bend their backs to any burden. They claimed to be lodged and combed like horses. Ox is a lion; ox is a leopard; ox is a bear; but his old character ox he has forgotten."

Nevertheless, even Gower, who disliked the crowd so much, believed that there were great evils which led to the trouble.

The Rebels and the Frightened Queen

Banding themselves together into a force of some 60,000, and arming themselves, the people started to march to London, Wat Tyler at their head. As this peasant army marched it grew in size, but on the whole it behaved well.

For instance, on the road to London the people met the Princess of Wales, the mother of the King, who was returning from a pilgrimage to Canterbury. They frightened the good lady, but otherwise did not molest her, and she was able to continue her journey to London. So remarkable was this that Froissart explains the matter by saying that "God preserved her."

It is true that as they went towards London Wat Tyler's followers burst into many manor houses, and ransacked them, and also put to death lawyers and other officials, whom they encountered. They regarded these men as their oppressors. When they found lists of villeins, or feudal serfs who were compelled by law to give so many days' work free to their lords, they burned these lists.


The death of Wat Tyler, from an ancient painting

At last the army reached Blackheath, a large open space outside London, close by where Greenwich Observatory now stands.

When news reached London that this great army, now numbering about 100,000, had encamped just across the river, there was much alarm. King Richard, with the Archbishop of Canterbury, the prelate who had imprisoned John Ball, and a number of nobles, shut themselves up in the Tower of London.

The wealthy citizens, hearing that Wat Tyler and his friends had declared that they would overthrow the Government and divide the wealth of the rich among the poor, looked upon Wat Tyler and his followers as a mob of robbers and plunderers, and they determined to keep them out of the city. They therefore shut the gates of London Bridge.

Young King Richard, who seems to have had a good deal of courage, rowed down the Thames to Rotherhithe, where 10,000 men had gathered, and when they saw his barge approach they set up a great shout. The King was advised by his barons not to land, but to have the barge rowed up and down the river.

"What do you want?" called out the King to the people. "I have come here to hear what you have to say."

"We want you to land," was the reply, "so that we can put our case before you."

The Earl of Salisbury, however, urged the King not to land, and called out to the people: "Sirs, you are not properly dressed, nor in a fit condition for the King to talk with you."

The barge rowed back to the Tower, and the people, seeing that they had failed to gain their way, went back angrily to Blackheath to report to their fellows.

"Let us march instantly to London," was the cry, and they immediately set off.

London Opens Its Gates

Now 30,000 of the people of London sympathised with the peasant army, and as the well-to-do citizens feared that these would rise and burn down their fine houses, they at last opened the gates.

The peasant army crossed the bridge and entered the city. There is no doubt that large numbers of them were decent people, who merely wanted the removal of the hardships which weighed down so heavily upon them. They were neither cruel nor bloodthirsty, and they sent messages to the King in the Tower, declaring that they respected and would obey him, but that they must lay their grievances before him, and they expressed the hope that he would set them right.

They made four requests: first, that they should no longer be slaves to another man, nor be compelled to give their work without payment; secondly, that the rent of the land they lived upon should be reasonable, that it should be paid in money, and that they should no longer be compelled, as they had been, to give work as payment for rent; in the third place, they asked that they should be free to buy and sell where they liked, and to take their

goods freely to market. Finally, they requested that none of them should be punished for what had been done since the rebellion broke out.

Meanwhile, things were not going so well in the city. The citizens who sympathised with the invaders, either out of fear or from mistaken kindness, gave them food and drink. And when the peasants had once tasted the strong wine they asked for more. As they drank, many of them grew wild and violent. At first, we are told, 'they did no hurt, and took nothing from any man," but soon certain speakers began to inflame them against John of Gaunt, and some of them went off to his palace of the Savoy, just outside London, and burned it down. Although it had in it much silver, gold and jewels, the mob did not steal anything. They even put to death as a thief a man who was found carrying some valuables away.

A Bad Night for London

Unfortunately, they found a great quantity of wine at the palace, and this they drank. As a result they became more wild than ever, and now began to kill many of the wealthy citizens.

It was a bad night for London, and when morning came it was felt that the mob must be appeased, or the city would be sacked. They demanded again to see the King, and it was agreed that he should meet them.

He was a boy of fifteen, but he was a spirited youth, and he sent word to the leaders that if they would retire with their followers to "a handsome meadow at Mile End, where in the summer time people go to amuse themselves," he would come out and meet them there.

About 60,000 of the peasants, therefore, went to Mile End, and on the way they behaved very well. There was no more murdering or looting. There they presented their fourfold petition to the King, and Richard promised faithfully to grant all their demands. He spoke to them calmly and sensibly, and we are told that "his word greatly appeased the more moderate of the multitude, who said, 'It is well, we wish for nothing more.'"

Large numbers of the people now began to return to their homes. But as is always the case, whenever a large crowd gathers together there is a sprinkling of hooligans whose one idea is plunder. They hope, in the confusion, to find robbery easy, and this was the case now.

Large numbers of the mob had not gone to Mile End at all, but remained behind in London, where they did some rioting and looting. Then they found their way into the Tower and killed the Archbishop of Canterbury.

On the following day, the King, who had ridden out to Westminster to hear mass in the Abbey church, was returning to the city, attended only by sixty horsemen, when he came upon the mob of 20,000 in Smithfield. He stopped and said he would not proceed until he knew what they wanted, and if they were in trouble he would try to help them.

Wat Tyler, seeing the King, said to his men, "Here is the King, I will go and speak with him. Do not stir from hence until I give you a signal." Then waving his hand he said, "When you shall see me make this sign, rush forward and kill everyone except the King, but do not hurt him, for he is young, and we can do what we please with him. By carrying him with us through England we shall be lords of it without any opposition."

The young king galloped up to the men. "Sirs," said he, "you shall have no captain but me"

Then he spurred his horse, and galloped up to the King, coming so near that his horse's head touched the crupper of the King's saddle.

"King," said Wat, "dost thou see all those men there?"

"Yes," replied the King. "Why dost thou ask?"

"Because," replied Wat, "they are all under my command, and have sworn by their faith and loyalty to do whatever I shall order."

"Very well," said the boy King. "I have no objections."

The Rebel Leader grows Insolent

Tyler answered: "Thinkest thou, King, that those people, and as many more who are in the city, also under my command, ought to depart without letters from thee? We will carry them with us."

"I have ordered," replied the King, "that the letters shall be delivered. But, friend, return to thy companions and tell them to depart from London."

Wat Tyler, looking round, saw a squire whom he hated, for at some former time the squire had ill-treated him, and they had had angry words together.

"What, art thou there?" cried Tyler insolently. "Give me thy dagger."

"I will not," said the squire. "Why should I give it thee?"

At this Richard turned to the squire and said, "Give it him," and the man gave it up, though much against his will. Tyler took it, and after turning it about in his hand, again addressed the squire insolently, saying, "Give me that sword."

"I will not," replied the squire, "for it is the King's sword, and thou art not worthy to bear it, who art but a mechanic; and if only thou and I were alone thou wouldst not have dared to say what thou hast, for as large a heap of gold as this church."

"By my troth," answered Tyler, "I will not eat this day before I have thy head."

At this William Walworth, Lord Mayor of London, rode up to Tyler and said, "Scoundrel, how darest thou thus behave in the presence of the King! I will not live a day if thou pay not for it!"

A Brave Lord Mayor

Whereupon he drew a short sword from under his cloak and felled Tyler to the ground. Another attendant of the King leaped off his horse and killed the peasants' leader.

An old story declares that William Walworth stabbed Tyler with his dagger, and that ever since a red dagger has formed part of the arms of the City of London. This, however, is not true, for the so-called dagger, which really represents the sword of St. Paul, was in the City arms long before Tyler's time.

The situation now became threatening, and when the crowd saw their leader lying dead on the ground they called out "They have killed our captain! Let us slay them all!"

But the young King saved the situation. At great risk to himself he spurred his horse and quite alone galloped up to the men, who were advancing.

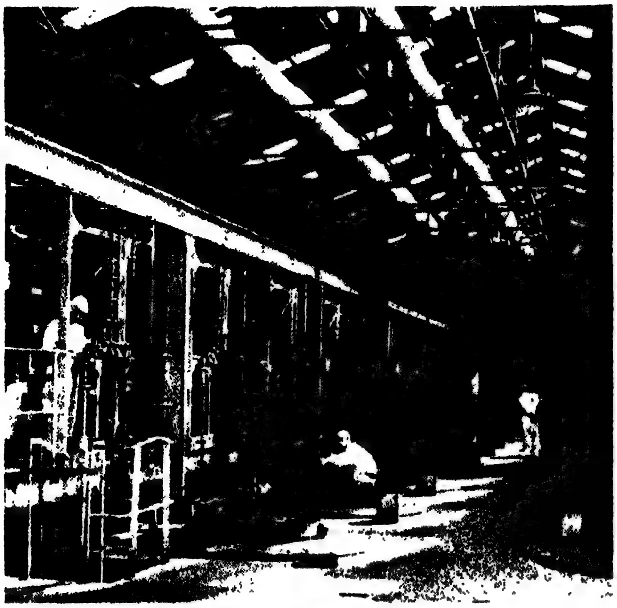
"Sirs," said he, "what are you about? You shall have no captain but me. I am your king. Remain peaceable."

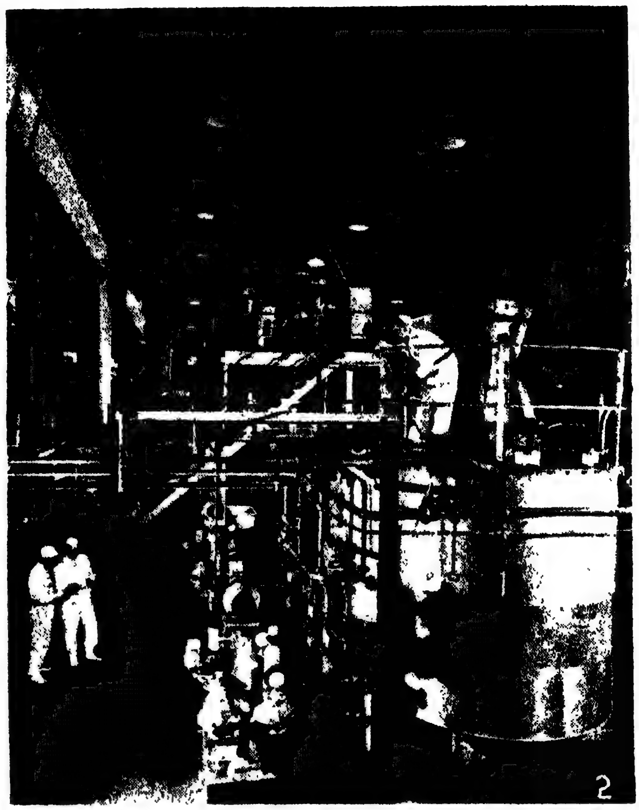
These words had their effect. The rioters stayed their hands. Some began to slink away and soon the rest dispersed and ran away in all directions. So ended the Peasants' Revolt of 1381.

It is sad to relate that the King who began so well listened to bad advice and did not keep his promises. The leaders, John Ball and Jack Straw, were beheaded, 1,500 others were also executed, and the villeins were not freed.

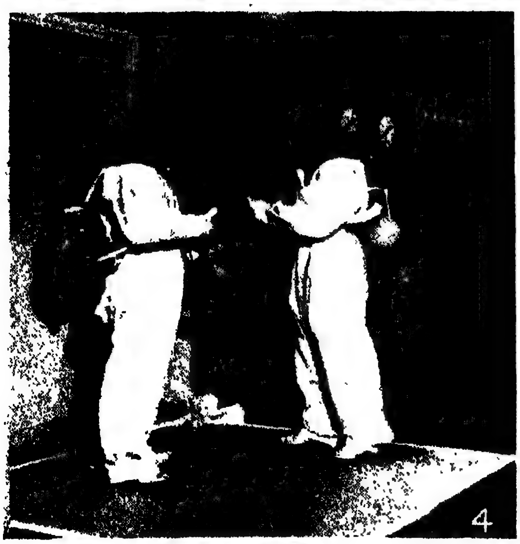
However, the insurrection had done some good, for the poll tax was entirely abolished, and although the villeins were not freed they were much better treated in the future, and the custom of paying them for their work, instead of compelling them to do it as slaves, came into practice; so that fifty years after the Black Death the English serfs at last secured freedom.

WHERE MEN WORK WITH ATOMS





Although the atom is so small that it is invisible even through the most powerful microscope, the plant and equipment necessary to convert atomic fission into useful energy is perhaps the most extensive, complex, and costly of any form of human activity. This is well-illustrated by these photographs taken at United Kingdom Atomic Energy establishments. 1. Furnaces for converting ammonium diuranate into metallic uranium. 2. Crude uranium oxide plant. 3. Turbo-alternators at Calder Hall atomic power station. 4. Technicians wearing breathing apparatus and protective clothing about to enter radio-active section of plutonium-producing plant. 5. Heat exchangers, Calder Hall



HOW WE GET THE GAS FOR OUR HOMES

The discovery that coal gas could be used for lighting streets and houses was one of the great steps forward in civilisation. It was the beginning of good lighting, for hitherto only dim oil lamps and candles had been available. When the rich entertained one of the greatest expenses was the cost of the wax candles, and the very poor had nothing but rushlights; that is, rushes dipped in tallow. Now the manufacture of gas is one of the great industries of the country, and in these pages we see how it is carried out

In many districts in recent years electricity has taken the place of gas for the lighting of streets and buildings. Gas, however, is still extensively used for this purpose, and as it is also now generally used for cooking and heating houses and is also very much used for driving engines, the amount of gas made and consumed is greater than ever

There are various by-products which occur in the manufacture of coal gas, and in early days it was a great problem to know how to get rid of this waste. Then some wonderful discoveries were made: the coal tar which had been looked upon as such a nuisance was found to contain all sorts of valuable materials, and now scores of these, including beautiful dyes, and even scents and flavourings, are made from the coal tar which is produced during the manufacture of the gas. Of these we read in another part of this book.

The whole process of gas making as it is carried out in our modern world is shown in picture form on the next two pages. But we can make gas on a small scale in our homes with no other apparatus or material than a long-stemmed clay pipe and a little finely-powdered coal dust.

Impure Gas from a Pipe

We put the coal dust in the bowl of the pipe, with perhaps a dab of earth or clay to cover it, and then we place the bowl between the bars of the fire grate, among the red hot cinders there. Presently some yellow, rather unpleasant-smelling smoke is seen to come out of the mouthpiece of the pipe. This is really coal gas, being given off from the coal dust in the bowl, and if we strike a match and put it to the gas it will burn at the mouth of the pipe. The pipe is really a gas-works on a small scale, and we have been distilling the coal.

Gas will be given off for a considerable time, and when at last it ceases, if we look in the bowl, we shall find that the dust is no longer coal but has become coke.

Gas manufacture, as carried out on such a large scale to-day, is really the distillation of coal, the collection and the cleansing of the gas given off till it becomes a colourless gas with very little smell, and the collection for various uses of the coke and the ammonia and other substances produced through distillation. A very large part of the profits derived from the making of gas is now obtained from the sale of the by-products, which were formerly thrown away as a nuisance.

It is said that coal gas in the form of natural gas escaping through cracks in the earth from coal mines has been known in China for hundreds, if not thousands, of years, and even in England in the early part of the eighteenth century a clergyman, the Rev. John Clayton, found that he could set light to the water in a certain ditch, so that it would burn like brandy, with a flame

A little gas-works in the home: making gas from coal in a clay pipe

so hot as to make it possible to boil eggs over it.

He dammed up the water in the ditch, and dug down into the earth, coming at last to a bed of coal. When a lighted candle was held against the hole it was found that what seemed to be air coming from the coal caught fire and burned.

Then Mr. Clayton collected some of this inflammable air in bladders, and he used to amuse his friends by pricking a hole in a bladder, squeezing it so that the gas inside came out, and setting light to it, when it would burn till all the gas had been pressed out.

Not, however, till the end of the eighteenth century was coal gas manufactured artificially from coal, but from the early part of the nineteenth century onwards progress was rapid, and in 1803 the Lyceum Theatre in London was lighted with gas, while four years later one side of Pall Mall was illuminated by the same means, and soon after the first gas company was formed.

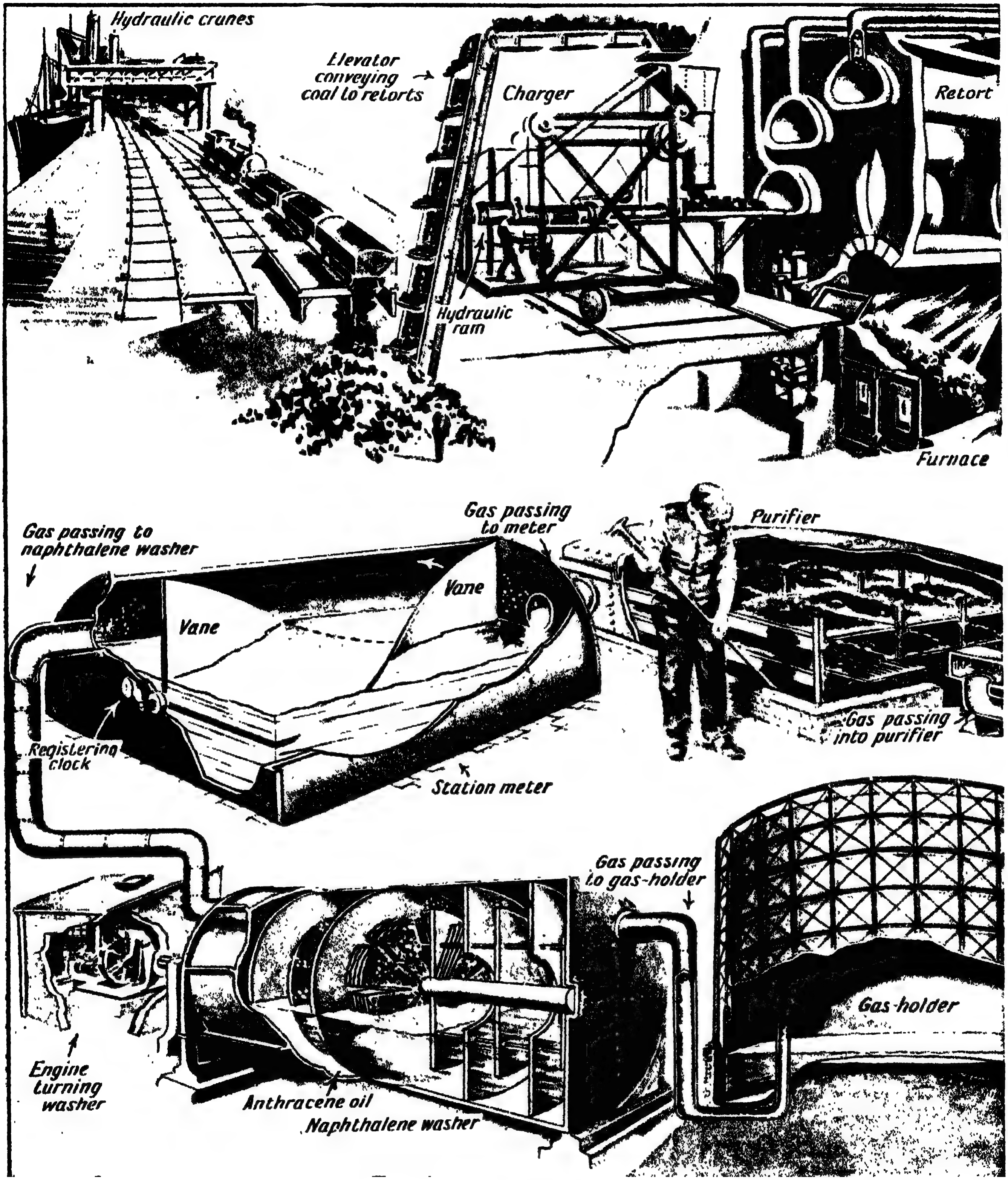
It is curious to read now that, according to its promoters' enthusiastic calculations, it would soon yield £229,000,000 of profit, nine-tenths of which was to be given towards the redemption of the National Debt, leaving a profit of £570 to be paid to the shareholders for every £5 which they had invested.

As a matter of fact, it was several years before the company paid any dividend at all, largely owing to the foolish opposition and prejudice of people in authority.

In talking about coal and the various products that are obtained from it by distillation at the gas-works we must remember that there are many different kinds of coal. Some varieties, for instance, like anthracite, are almost pure carbon and contain practically no gas. That is why anthracite burns in a slow-combustion stove only with a red glow without any flame. Other kinds of coal contain a great deal of gas, and these are used for the production of illuminating gas. Between the two extremes are many varieties containing all degrees of gas.

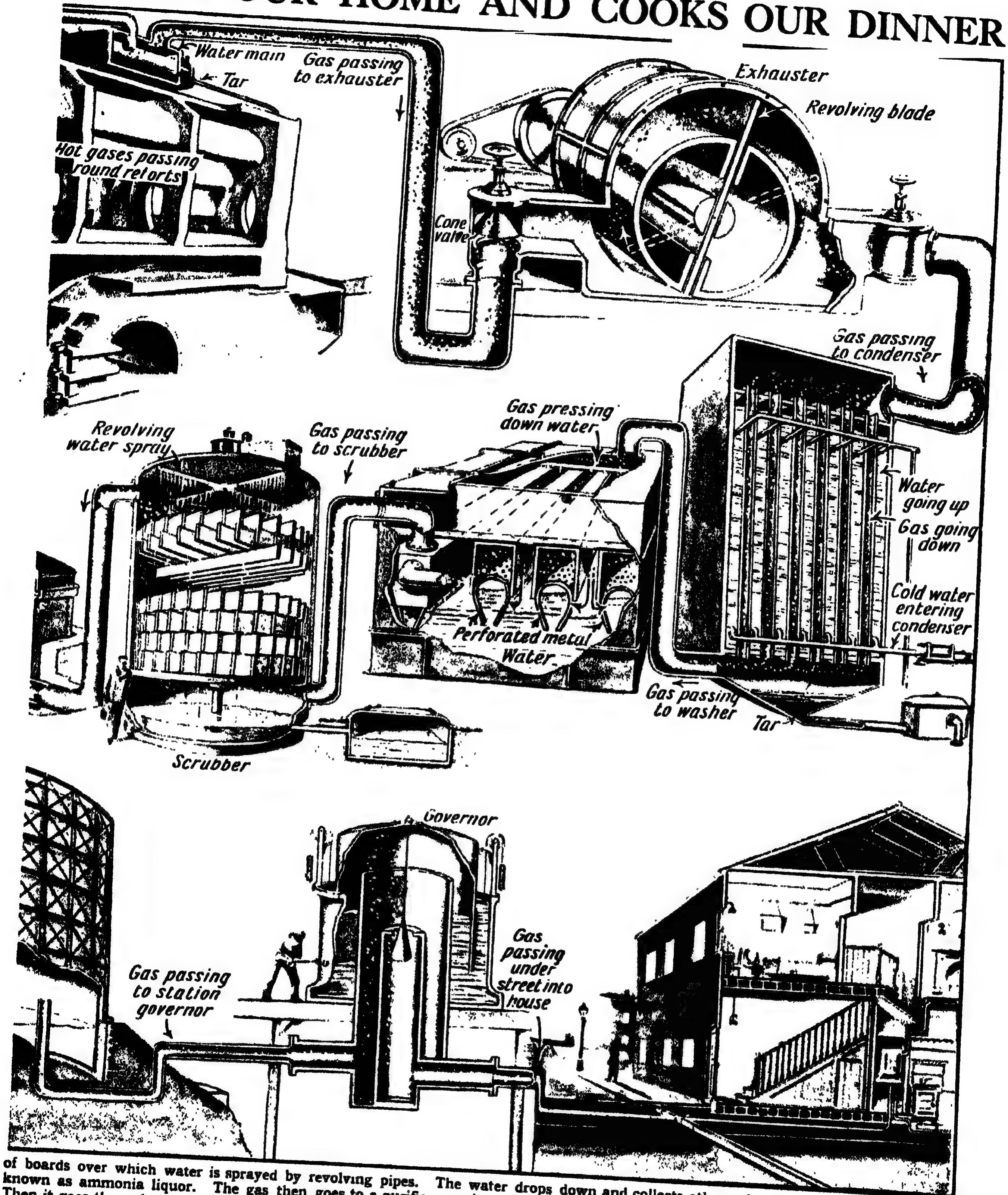
It can be understood, therefore, that the quantity and quality of the gas obtained, and the nature and relative amounts of other products that are recovered, depend upon the kind of coal that is being used at the gas-works. But these things vary also according to the conditions and temperature under which the coal is distilled. Even the size and shape of the retort affects the products. For the production of illuminating gas, the coal is distilled at temperatures as high as 1,830 degrees Fahrenheit.

HOW WE GET THE GAS THAT HEATS AND



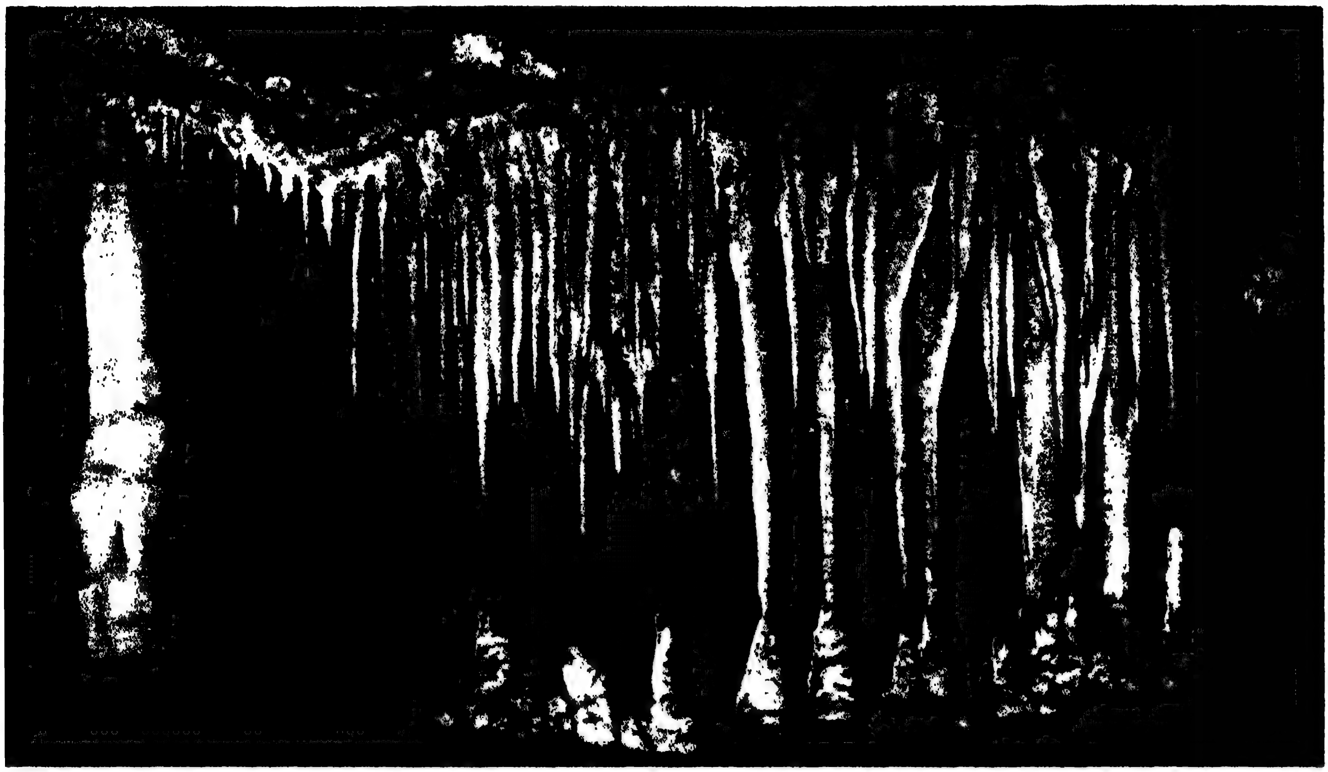
On these pages we show how gas is produced from coal and sent into our homes. The pictures largely explain themselves. Starting at the top left-hand corner, a coal ship has arrived at the wharf and is unloaded by grab-cranes into a hopper so that the coal can be dropped into waggons. The waggons are pushed towards a mechanical conveyor or elevator which feeds coal into an automatic charger. A hydraulic ram then pushes it into a retort, where heat extracts the gas from the coal. The gas is very impure and is passed through a water main where tar is deposited and collected. Then it goes through a valve into the exhauster, an ingenious apparatus consisting of one drum within another. The inner drum turns and within it revolves a blade which moves up and down and pushes the gas through a pipe into a condenser. Here cold water passing upward through pipes condenses further tar, which is collected, and the gas passes down through a pipe into a washer. It travels down spaces between boxes containing perforated metal tubes. Then it goes through the perforations and passes through water to a scrubber. It enters at the bottom and goes up through a staging

LIGHTS OUR HOME AND COOKS OUR DINNER



of boards over which water is sprayed by revolving pipes. The water drops down and collects other valuable constituents, becoming known as ammonia liquor. The gas then goes to a purifier, passing over trays of oxide of iron which absorbs the sulphur impurities. Then it goes through a meter with curved vanes which, as they move round, drive the gas below water and into a naphthalene washer. The quantity passing the meter is registered on a dial. In the washer a dangerous material is taken from the gas as it passes through perforated sheets of absorbent material soaked in oil. These revolve as the gas passes on. It is now ready for use, and is stored in a gas holder (often erroneously called a gasometer). Then it passes a station governor which controls the amount sent to any particular district, and eventually enters the mains under the streets and comes into our homes for use. The various bye-products collected in the making of the gas were once a nuisance, as it was difficult to dispose of them, but now they are of great value and yield scents, dyes, and other commodities, such as road-making material and high explosives such as tri-nitro-toluene, more generally called trotyl or T.N.T.

STONE PILLARS BUILT UP THROUGH THE CENTURIES



Here is a wonderful example of stalactites to be seen in the Jenolan Caves of New South Wales. The stalactites are very evenly formed and, as can be seen, they have in some cases met the stalagmites, rising from the floor of the cave. The old proverb says "A continual dropping wears away stone," but in this case it is the continued dropping of the water over many years that has built up the stone pillars

This picture shows the Paradise Grotto in the Postumia or Adelsberg Cave in Italy. The stalactites take on a much more rugged form than in the upper photograph. They have been centuries in the making, for this grotto was known and written about in the Middle Ages, but for many years its position was forgotten. Then it was rediscovered in 1818, since when it has become a popular show-place. Stalactites are generally much larger than stalagmites, because most of the water evaporates before it reaches the ground

WONDERS of LAND & WATER

WHAT THE ICICLES OF STONE TELL US

Everyone admires the festoons of crystal-like rock that hang in limestone caves and are known by the name of stalactites, and also the erect pointed pillars that are called stalagmites. These always look very dazzling when lighted up by flashlight. But in addition to admiring natural formations, we ought to know how they are formed and in these pages we see the stalactites and stalagmites and learn the story of their growth

In many of the limestone caves of the world there hang from the ceiling long tapering pendants of stone, which for all the world resemble icicles in shape. It is quite easy to understand how they have been formed.

When the rain falls it begins as pure water, but as it passes through the atmosphere it dissolves some of the gases in the air. Then when it reaches the ground and begins to sink through the soil it dissolves still more impurities obtained from decaying plants.

This process makes the water capable of dissolving mineral matter, and so, as it passes through the rocks, it dissolves more and more of their substance and becomes what we term "hard." One gas which the water absorbs in this way is carbon-dioxide and when the water contains that gas it will dissolve limestone

Why Water is Hard

We know what hard water is: in many districts the water that flows from our taps is hard water, that is, it has dissolved in it a large quantity of mineral matter. When we boil this water in the kettle it gives up a great deal of the mineral matter, which gets deposited round the inside of the kettle and in the spout.

In some places the water is so hard that kitchen boilers have to be scraped and cleaned out once every six months, and even teapot spouts become clogged with mineral matter.

Now when hard water such as we have described flows through a layer of limestone rock into a cave it has a good deal of limestone in it, and as the water hangs in drops from the roof of the cave some of it evaporates The solid matter in solution is then deposited on the roof of the cave. Gradually there is quite a bump of this formed and as the drops hang from the bottom of the bump more limestone is deposited till at last what was a mere bump or boss becomes a pendant like an icicle, but made of rock instead of ice.

When the drops fall on to the floor of the cave there, again, the water evaporates and the solid matter is left behind. Here the same thing happens, only in the opposite direction. First a bump is formed, then this gradually gets added to, till at last there is an upright pillar of rock, and if the dripping goes on long enough the pendant and the pillar will eventually meet and form a continuous column from the floor to the roof. There are caves where such pillars are to be seen, while in others the roof is festooned with pendants and the ground covered with growing uprights.

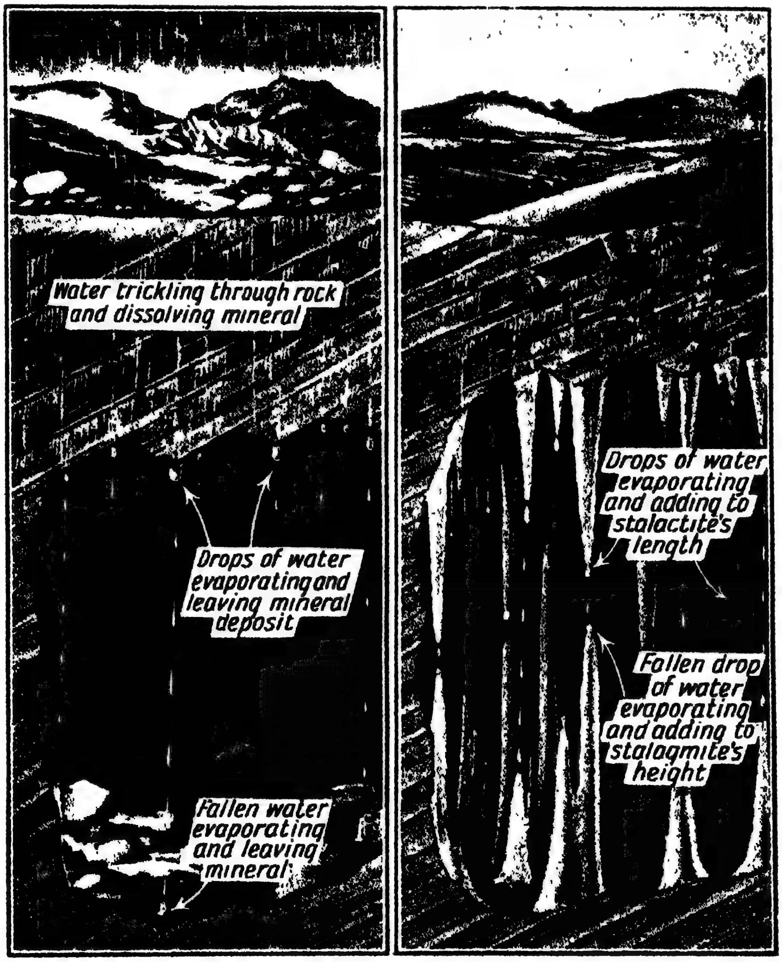
Those rocky forms which hang from the ceiling are called stalactites, which comes from a Greek word, stalaktos, meaning a "trickling" or a "dripping." The upright deposits are called stalagmites, which comes from another Greek word, stalagmos, also meaning "a dripping."

Stalactites on Arches

Many of these caves with stalactites and stalagmites are very beautiful, and when lighted up look like fairyland. Such caves are to be seen in England and abroad.

Sometimes little stalactites are seen hanging like icicles from the roof of the arches of a railway bridge. They are formed in exactly the same way as those in the caves, the rainwater which trickles through the bridge dissolving the lime matter in the material of the roadway or the arch.

Now a very interesting thing about these icicles of stone is that they can be used as geological timekeepers. By studying



In these pictures we see how stalactites and stalagmites are formed Rainwater trickling through the limestone rock dissolves the mineral, and as the drops of water hang from the roof of a cave the moisture evaporates, leaving the mineral matter behind. Some of the drops fall to the floor and evaporate there, leaving a deposit of mineral matter in that position. As through the centuries drop after drop falls, these deposits increase in size and become stalactites and stalagmites. The picture on the right shows a scene thousands of years after that in the picture on the left. The cave has become bigger through more of the limestone being dissolved, the stalactites and stalagmites have become longer, while the prehistoric scenery above ground has become a cultivated landscape and the hills have become smoothed down by weather action

them men of science are able to tell us how long the water has been trickling through the roof of the cave.

We know how icicles vary in appearance. Some are beautifully smooth and well formed, while others are rough. Then, again, some are thick and stubby, while others are thin and graceful. The same thing is true of stalactites and stalagmites, and it is by taking note of these appearances that the scientist can tell how long the rocky icicle has been growing, from its birth to the present day.

When the stalactites and stalagmites are smooth and symmetrical in form it is clear that the water has been dripping at an even rate for a very long time, probably at the same rate as it is still found to be dripping. If, then, we know the size and rate of the drip, the temperature of the cave, and the movements of the air, it is possible, by very careful calculations, to know how long the stalactites and stalagmites in the cave have taken to grow to their present dimensions. Geologists tell us that one big stalagmite in the Wyandotte Cave in Indiana took 30,500 years to reach its present state.

HOW MAN IS CHANGING THE EARTH'S FACE

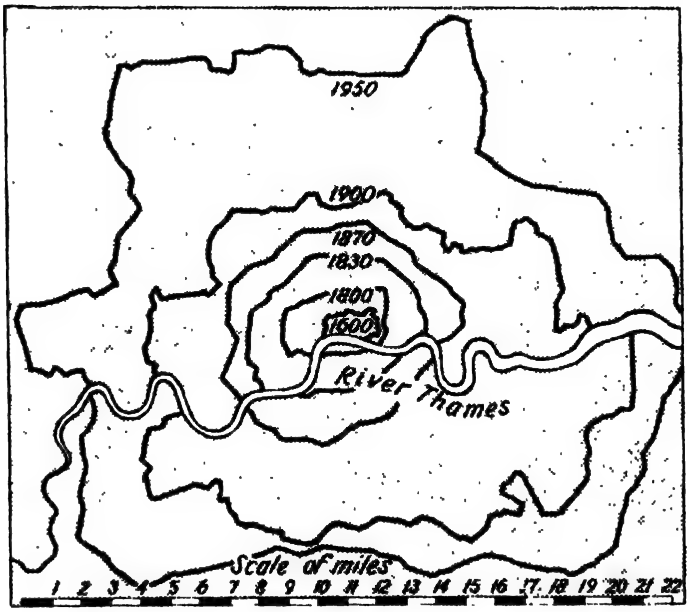
Ever since man arrived on the Earth he has, by his actions, been changing the appearance of its surface. At first the change was very slight and very slow, but nowadays a whole landscape is completely transformed in a year or two. How great the changes are can be seen more clearly since the advent of aircraft, for a photograph taken from the air gives a far better idea of the general character of a large area of country than any number of photographs taken at the level of the ground.

To realise the changes wrought by man in the physical appearance of the Earth we have no need to go beyond the confines of England. Two thousand years ago almost the whole island of Britain was one big forest, and could it have been viewed from the air, it would have had very much the appearance of the Amazon forest to-day. There would have been seen miles and miles of thick foliage, with scarcely any clear spaces save where the rivers wended their way to the sea.

Even these rivers would not have appeared as the silver winding ribbons that they look to-day when seen from a height. Man has been largely responsible for confining them closely within well-defined banks. He has dredged the channels and built embankments so that, except at rare periods of unusually heavy rainfall, the waters do not trespass on the land, but make their way to the sea within their appointed limits.

But when the Romans first came to Britain, a river like the Thames did not run in this orderly manner between its banks. Its course became a swamp, especially in the lower half of its length. There were marshes everywhere, and the river constantly overflowed and flooded large areas. "The Thames," says Mr. G. R. Stirling Taylor, an authority on historic London, "was merely the main waterbed of a marshy swamp, which covered a large part of what is now solid South London and made Westminster (or rather, would have made it, if it had been there) a little island, and Chelsea a mere peak of land running into the water; while on the east side the River Lea with its marshes repeated the picture."

In short, adds Mr. Taylor, London was in those days of the Roman invasion a low headland on the northern side of the Thames marshes; which became London mainly because it was the highest and safest plot of land within a reasonable distance of the first fordable place, Westminster, on the natural highway of the Thames.



This diagram shows the amazing growth of London through the centuries. In the past hundred years the great city has increased its area fifty times more than it did in the previous two centuries. A hundred years ago the whole of the country shown in the picture, except the small central part, was a rural district. Now it is covered with streets and houses

The highway remains, but how the country along its banks has changed! A vast city consisting of continuous streets of buildings now stretches for many miles in all directions; other cities and towns stand along the banks, and the country adjoining, instead of being covered by forest, is laid out in well-ordered cultivated fields.

What is true of the Thames valley is true also of most other parts of the country. In the north of England hundreds of square miles have become industrial areas covered with mines, and towns, and factories, and tall chimneys belching out volumes of black smoke, making what was once a beautiful rural area into a dingy black country with little to recommend it to the artistic eye.

And this kind of thing is going on in nearly every country of the world and at an ever increasing rate. Lands that a century or more ago were almost uninhabited, with wild, untilled landscape, are now thickly populated and have cities with hundreds of thousands, and sometimes millions, of inhabitants, while instead of forest or bush or desert country there are now cultivated and irrigated regions producing rich crops. We find this in Australia and New Zealand, in North and South America, and in some parts of Africa, as well as in Eastern Asia.

Think of the quiet, sylvan scene two or three hundred years ago in the districts now covered by New York and Chicago and Detroit, and Los Angeles and Philadelphia, and Sydney and Melbourne, and Buenos Aires and Rio de Janeiro, and Glasgow and Birmingham, and Leningrad, to mention only a few. Of course, Greater London still remains the biggest city in the world with more than eight million inhabitants living in houses in practically continuous streets.

Man changes the face of the Earth by all sorts of means. In addition to building cities and cultivating the soil, he changes the course of rivers, putting some of them underground like the waterways of London, the Fleet River or Hole Bourn, and so on; he drains or fills up swamps and lakes, he makes new lakes, as when he dams up a river to form a reservoir for a town's water supply or for the generation of hydro-electric power; he checks the erosion of the sea, and by removing forests he changes the climate.

In the Netherlands thousands of acres have been won from the seabed by building dykes.

THE WAY IN WHICH THE DEW IS FORMED

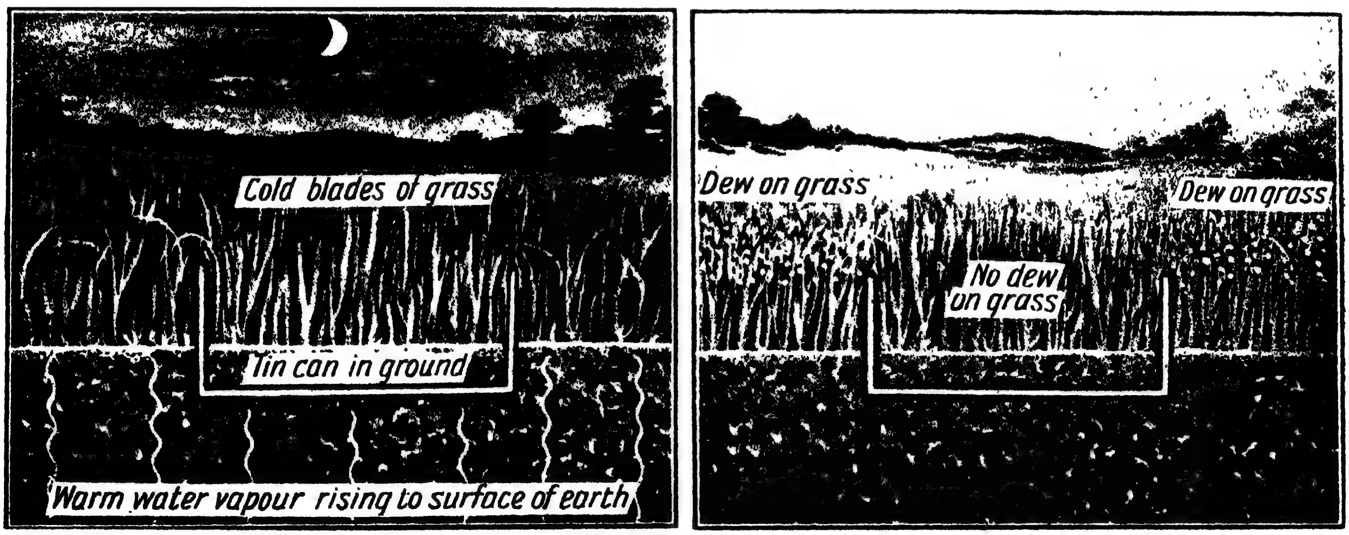
Dew, as everybody knows, consists of small drops of water which gather on leaves, the blades of grass, the threads of spiders' webs, and indeed on most objects that are out in the open at night. The drops are condensed from water vapour, but up to recent times it has not been known definitely how the dew was formed, that is, the source of the vapour from which the dewdrops condensed

The experiments carried out by a Cambridge scientist were very interesting, and are shown in picture form on this page. First of all he inverted a tin over certain blades of grass, letting the tin into the ground to shield these blades from the atmosphere. In the morning he found that the grass all round the tin was covered with drops of dew, but when he raised the tin the grass underneath had no dew whatever

blades, but lowered it into the ground, replacing the turf in the tin The next morning when he examined the place he found that the grass all round the tin was covered with dewdrops, while that in the tin had no dew whatever.

On this occasion the moisture had risen from the ground and had been precipitated as drops of water on the blades of grass. But where the moisture could not rise because of the interven-

In the left-hand picture the tin, shown in section, was inverted over the grass as evening fell, and the next morning dew was found on the grass all round, as shown on the right, but when the tin was removed there was no dew on the grass under the tin. This showed that the dew was precipitated from the air and the grass under the tin was dry because the moist air could not get to it



In this experiment the tin was let into the ground, the grass being replaced in the tin as shown on the left. The next morning there was dew on the grass all round, but no dew on the grass that had the tin under it. In this case it was clear that the dew was not precipitated from the air, but was caused by moisture rising from the soil. No moisture could rise where the tin acted as a barrier

Poets used to write about the dew "falling," but dew does not fall like rain. The vapour all round the grass and leaves suddenly becomes chilled, and, as a result, condenses into drops of water. It was supposed for a long time that all this moisture came from the atmosphere, but recent experiments have shown that this is not the case.

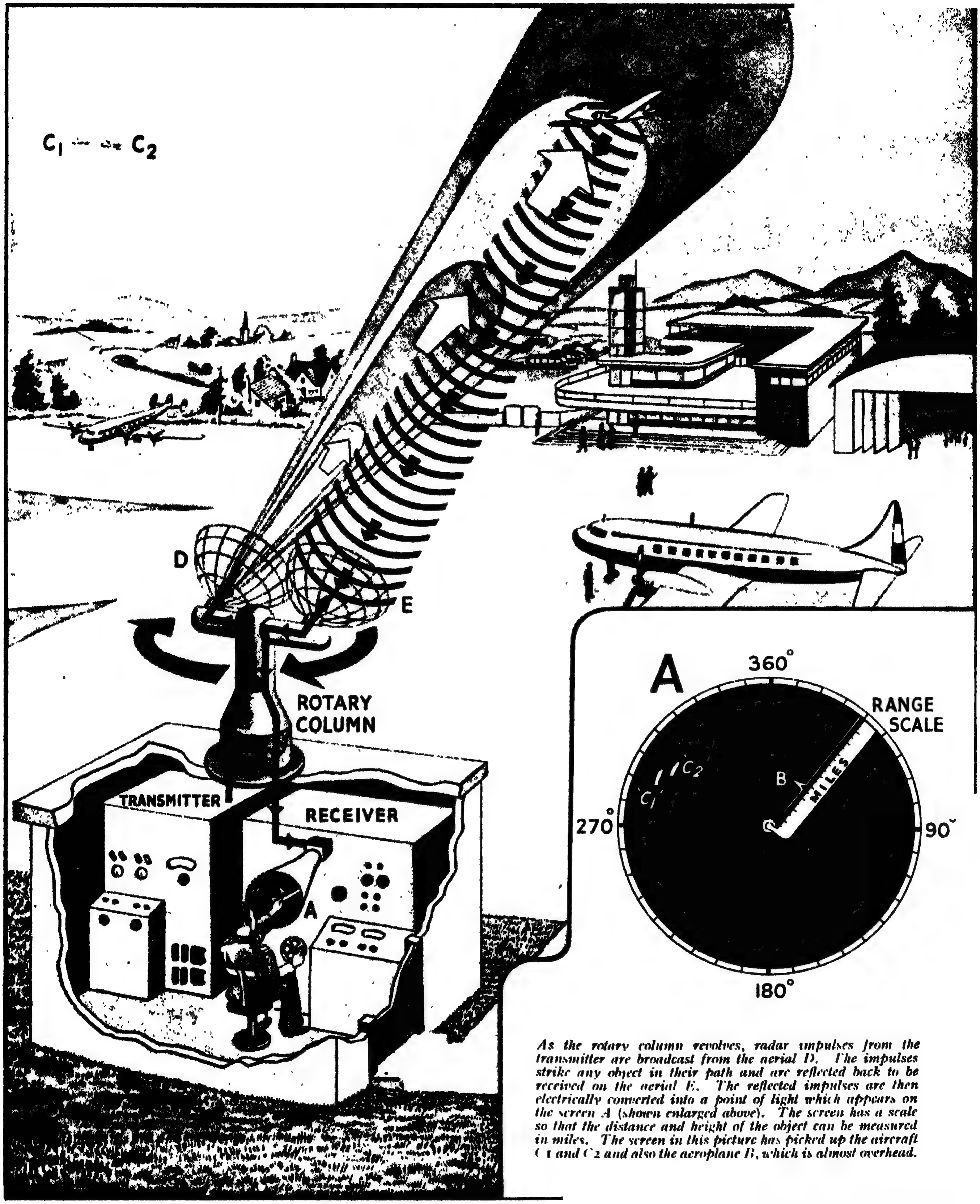
upon it. It was clear therefore that in this case the dew had been derived from the moisture in the atmosphere, that it had not "risen from the ground," as many people suppose the dew always does.

On another night the scientist carried out a second experiment. This time he did not invert the tin over the grass

tion of the tin the grass thus protected had no dew whatever.

The experiments described read remarkably like the story in the Book of Judges, of Gideon and the fleece which he laid out at night. On one night the fleece was covered with dew but not the surrounding ground, while on the next night the ground was dewy but not the fleece.

HOW RADAR DRAWS PICTURES OF ECHOES



As the rotary column revolves, radar impulses from the transmitter are broadcast from the aerial D. The impulses strike any object in their path and are reflected back to be received on the aerial E. The reflected impulses are then electrically converted into a point of light which appears on the screen A (shown enlarged above). The screen has a scale so that the distance and height of the object can be measured in miles. The screen in this picture has picked up the aircraft C 1 and C 2 and also the aeroplane B, which is almost overhead.

The full story of radar is told elsewhere in this work. The picture diagram above shows one of the many applications of this wonderful invention ; finding the number and the position of aircraft flying over a civil aerodrome

SEAWEEDS THAT ARE GOOD FOR FOOD

There are all kinds of free foods that grow wild in the English countryside. Some are the berries of flowering plants, like the blackberry, bilberry, wild strawberry, and so on. Then there are leaves which make excellent salads, such as those of the dandelion and succory. Many funguses, too, are edible, but few people know that there are a number of seaweeds found round the British coasts which make good eating

When we stand on the beach and see various kinds of seaweeds washed up on the shore or growing round the pier and groynes, we rarely think of these as food. Yet there are several kinds of seaweeds found round the coasts of Great Britain and Ireland which form excellent foods.

Chief among these is the Irish or carrageen moss, which varies in colour from brownish purple to yellowish green. Boiled in water and strained it produces an excellent jelly, which can be boiled up again with milk, spice, sugar and lemon-peel. It is also used to make blancmanges. Large quantities of it are gathered along the Irish and Scottish coasts, dried in the sun and then sent to various parts of the country for sale.

There are two kinds of edible laver, the purple laver and the green laver. The first of these, when boiled, becomes dark brown, and has a very delicate flavour. The green laver, sometimes called sea spinach, also makes an excellent vegetable, but is less delicate in flavour. This turns olive green when boiled. Both should be cooked for several hours, and served with butter, pepper, lemon-juice or vinegar, and they must be eaten hot.

A relation of the purple laver, and very similar to it, is the Porphyra lacinata, which has no popular name. It can be cooked in the same way.

Another edible seaweed which is much eaten in Ireland and Scotland is the purple dulse, or dillesk. This must be washed thoroughly in fresh water, and dried in the sun, when it can be eaten raw, or boiled in milk, with rye meal.

The olive-coloured alaria, which has the popular names of badderlocks and murlins, is also a useful plant which can be boiled and eaten. The oil, which its seed vessels and air vessels contain, is said to be highly beneficial to people suffering from rheumatism.

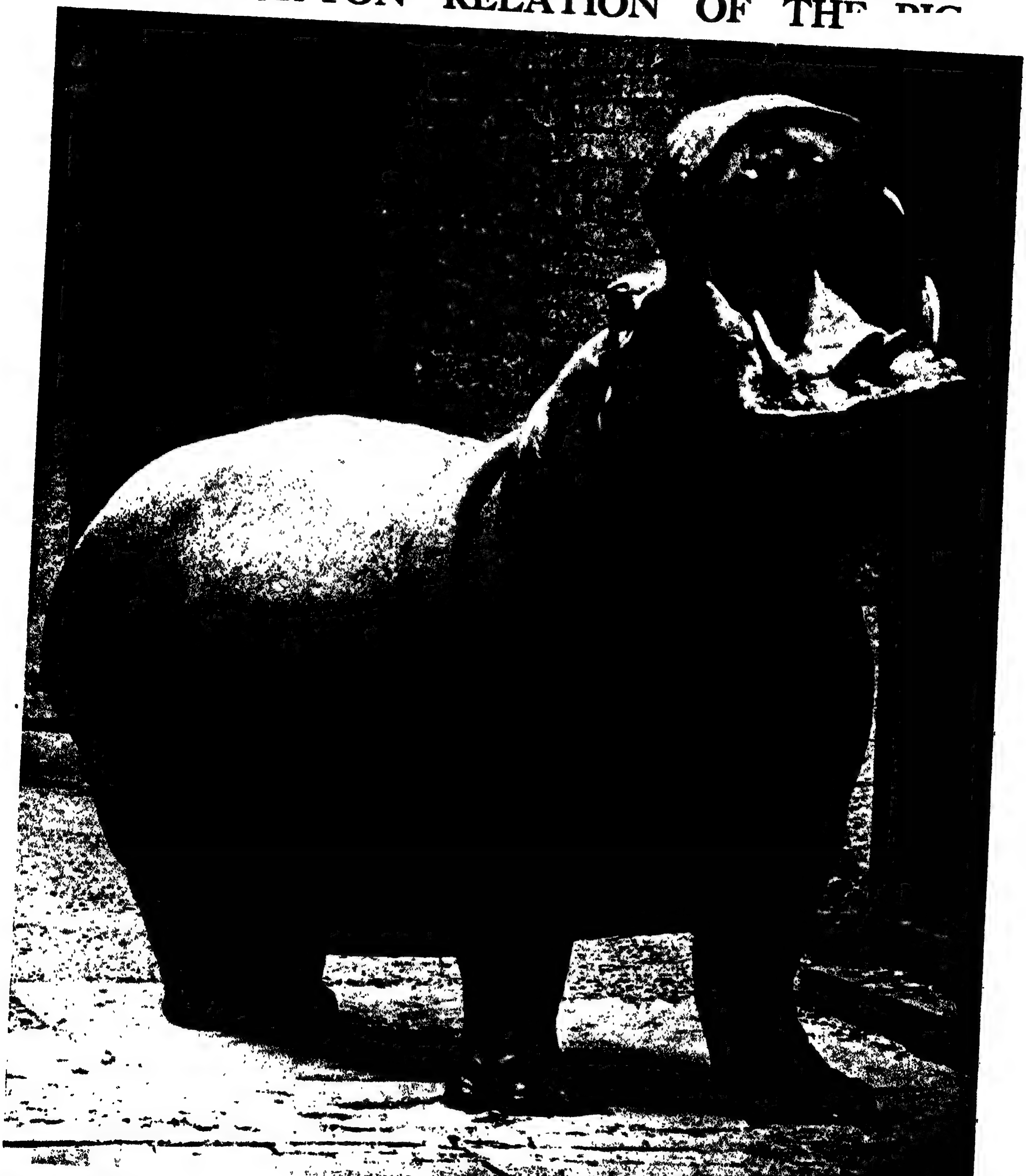
The long, brown laminaria, known to children by such names as sea-girdles, Venus's girdles, tangle, ladies' ribbons, and donkeys' tails, provides a wholesome food, the young leaves and stems being boiled as a vegetable.

There are two species of brown fucus, one being known as the bladderwrack and the other as the serrated fucus. These are boiled and eaten as vegetables, and the oil they contain is of benefit to delicate people.

It must be remembered that the agar-agar or Japanese isinglass, which is bought in the grocers' shops for making jellies, and is also used in giving a good consistency to jam, is only a dried seaweed.

Here are some of the familiar seaweeds of our British coasts which form excellent foods when cooked. They are: (1) Bladderwrack (Fucus nodosus); (2) Green laver (Ulva latissima); (3) Carrageen or Irish moss (Chondrus crispus); (4) Dulse (Rhodymenia palmata); (5) Porphyra lacinata; (6) Serrated fucus (Fucus serratus); (7) Purple laver (Porphyra vulgaris); (8) Venus's girdles (Laminaria digitata); (9) Badderlocks or murlins (Alaria esculenta); (10) Fucus canaliculatus

A FOUR-TON RELATION OF THE PIG



The hippopotamus is a near relation of the pig, but its name means "river horse." Why it was given this name it is difficult to say, for it certainly has very little resemblance to a horse, and spends most of its time in the rivers where it lives. It is a hoofed animal, and is of enormous size and weight, although there is a dwarf species which is only six feet long. The hippopotamus has a round, barrel-like body, often over fourteen feet long, and some specimens weigh more than four tons. Its two chief features are its thick hide and its huge mouth. In some animals the weight of the hide is over a quarter of a ton. The mouth, when open, looks like a huge red cavern, and the canine teeth or tusks are often two-and-a-half feet long. The jaws are as powerful as they look, and an angry hippopotamus has been known to bite a boat in two. Yet, although so formidable, it is a vegetarian. In the Nile this giant is often seen swimming as fast as a steamboat. Thousands of years ago the hippopotamus used to roam where London now stands.

THE WONDERFUL STORY OF THE COCONUT

One of the most remarkable plants in the world is the coconut palm. Its life is a great romance from beginning to end, and in these pages we read the story of how it resists its enemies, protects its young, and performs many useful services for mankind. At one time the only interest the civilised countries of Europe had in the coconut was to use it for cock-shies and to eat the rather indigestible nut. It was, of course, a favourite with boys and girls. But now it is one of the most important articles of commerce, and more than 26 million hundredweights of coconut oil and dried kernels are used in industry every year, and hundreds of thousands of people are engaged in manufactures in which the coconut is used in some form

All boys and girls are fond of coconut. It is the biggest of all the nuts, so that we can cut and come again, and it is, on account of its use in the coconut-shy at the fair, for ever associated with merriment and jollity.

But apart from the pleasure it gives us, the coconut is indeed a very wonderful fruit. It grows on a tall palm and is found in tropical countries round the seashore. The name was given to it by the Portuguese because, with the three marks or eye-spots at the end, it looked something like a monkey's face, and "coco" is the Portuguese word for a bugbear or distorted mask.

A Universal Provider

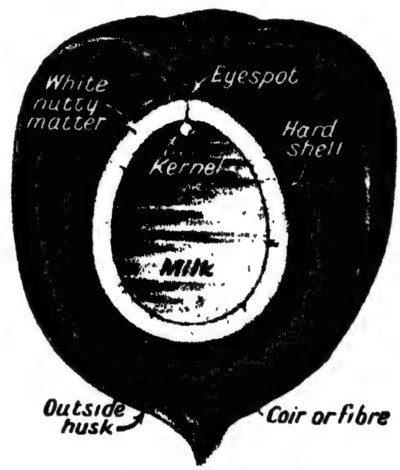
The coconut palm often grows over a hundred feet high, and has at the top a crown of large feather-like leaves twenty feet long. The flowers are white, and the nuts when they form are in huge bunches of from twelve to twenty.

It is doubtful if any other plant in the world is useful to man in so many ways. A Chinese proverb declares that there are as many useful properties in the coconut palm as there are days in the year, and the Polynesians have a saying that the man who plants a coconut plants meat and drink, hearth and home, vessels and clothing for himself and his children after him.

Indeed, the coconut palm is a universal provider, and not only the untutored savage and the natives of the lands where it grows benefit by it, but the people of civilised lands make use of the coconut every day of the year.

How coconuts grow on the tops of palms

In hot countries the solid white part of the nut gives food to thousands of people, while the milk, or liquid inside the shell, provides them with drink. It has been pointed out that the coconut really acts as a filter to the water of malarious regions, for the roots absorb polluted liquid and purify it before passing it on to the nut.



The inside of a coconut as it grows

The flower stalk yields a sweet juice which is boiled down to produce a useful sugar. Or the juice can be fermented to produce a spirit known as toddy or arrack. By squeezing the dry nut we get coconut oil, which is an excellent substitute for lard in the frying-pan, and for butter on the tropical breakfast table

Candles, Soap, and Margarine

The kernel of the coconut is broken into small pieces and then dried in the sun. This substance is the well-known copra, which is the principal export from many tropical lands. Vast quantities of it are imported into civilised countries, and from the oil which it yields are made candles, soap, and margarine. During the purification process glycerine is obtained. From 500 gallons of copra 25 gallons of coconut oil are produced.

But the outside or husk is also most useful. The fibre surrounding the nut yields coir, which is made into ropes or woven into matting and doormats. Brushes and brooms are also made from it, and it provides an excellent stuffing for cushions. In tropical countries the hard shell is cut in half to provide two useful cups.

The leaves of the coconut palm are used for thatching, while the leaf-stalks constitute excellent rafters or posts for fencing. The fibrous sheath at the base of the leaf is a natural cloth, and is employed for clothing, for native hats, and for strainers. The timber of the tree is a good cabinet-maker's material. The flat plates of the leaves yield the writing material on which many of the Buddhist manuscripts are inscribed.

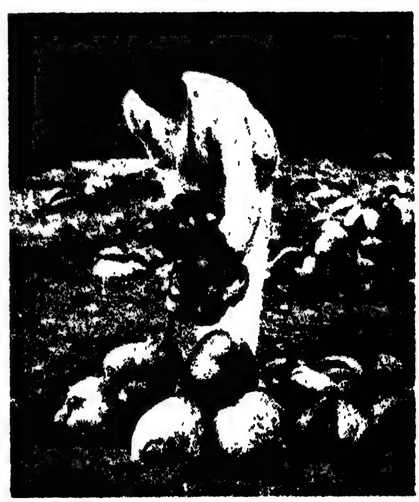
These are only a few of the uses to which the wonderful coconut is put for the benefit of man. Its wonder, however, is not confined to its many uses. When we examine the nut and know its life-story, we marvel more than ever.

Providing Against Accident

In the first place, it grows so high up that if it were an ordinary nut, when it fell ninety or a hundred feet on to what is often hard ground, it would crack and be ruined. The coconut, however, has provided against such an accident. Outside the hard shell there is a mass of husk which acts as a spring, and breaks the fall when it lands on the ground.

The coconut has many parts; first an outer skin, then a fibrous covering, next a hard woody shell; then there is the nutty portion which we eat, and finally the liquid or milk with the single seed or embryo from which a new coconut palm may eventually grow.

How did the milk get into the nut? Let us look a little farther into its history. The coconut is so appetising that it has many enemies who would



Collecting coconut husks in British Guiana

like to eat it. These are found not only among the human kind, but also among the monkeys and a species of crab that climbs trees. The nut, therefore, if it is to survive and produce a new tree, must take great care of itself. We have seen that it protects its shell from getting cracked by a cushion-like covering of fibre; but if the shell is so hard how is the young plant, when it sprouts, to get out of the shell? How indeed is it to start sprouting, seeing that no water can get in?

Three Brown Pits

If we look at the narrow end of a coconut we notice three little brown pits on the surface. Two of these are stopped up by quite hard material, but the third one has a very thin covering which can be easily bored through with a pocket knife. Boys often do this to let out the milk before cracking the shell.

Now if we examine a coconut we shall find that opposite to this soft hole inside there is a small knob buried in the eatable part of the coconut. That knob is the embryo, or seedling palm, for whose benefit and protection the nut exists. The hole with the soft covering is not really to let out the milk, but to let out the seedling.

The Milk in the Nut

Now, as the seed cannot get water from outside, the nut has had to provide a good supply inside, and that is the real reason for the milk being in the coconut. As already explained, the water is taken in through the roots, travels up the trunk, and after being filtered, is deposited inside the nut.

The kind of tree the coconut grows on. A group of coconut palms in Ellice Islands with a native climbing up to gather the nuts

The hard nutty part of the coconut which we eat is really deposited on the inside of the shell by the milk. Directly the seed begins to sprout the little knob, at first so small, begins to swell, absorbing the liquid till it eventually becomes a big, spongy mass which fills up the whole of the inside of the shell. At the same time a little sprout pushes its way out of the soft hole and produces a bud, the future stem and leaves of a coconut palm. Inside, a number of long threads absorb the water of the liquid and these are the future roots of the tree.

But as the little plant grows the spongy mass inside the nut begins to absorb all the nutty part, which we find so appetising, and uses its store of oils and starches to feed the young plant until it is old enough to open its leaves to the sunshine, and send its roots into the ground to obtain its own nourishment.

We may ask why there should be three eye-holes at the end of the coconut, seeing that only one is required. Well, at one time the coconut palm did not know so well how to protect its seed, and like many other plants, used to produce a number of seeds so that, at any rate, one might survive. Plants which provide little or no protection for their seeds produce very many seeds, so that one in a hundred or a thousand may survive.

In earlier days the coconut must have contained three seeds or kernels, but as the protection was improved it was not necessary to produce so many, and so two of the seeds were dispensed with and more attention was given to providing for the one remaining. Indeed, it has been said that the coconut has the largest and most richly stored seed of any known plant.

One Favoured Child

In this behaviour the coconut is doing what many human beings do to-day. Instead of having large families and leaving the children more or less to shift for themselves, they have only one child, who is given the very best of education and attention.

As the two eye-spots where the other seeds used to find their outlet are not required, the coconut has grown hard coverings over these, which makes it less easy for enemies to find a way into the coconut.

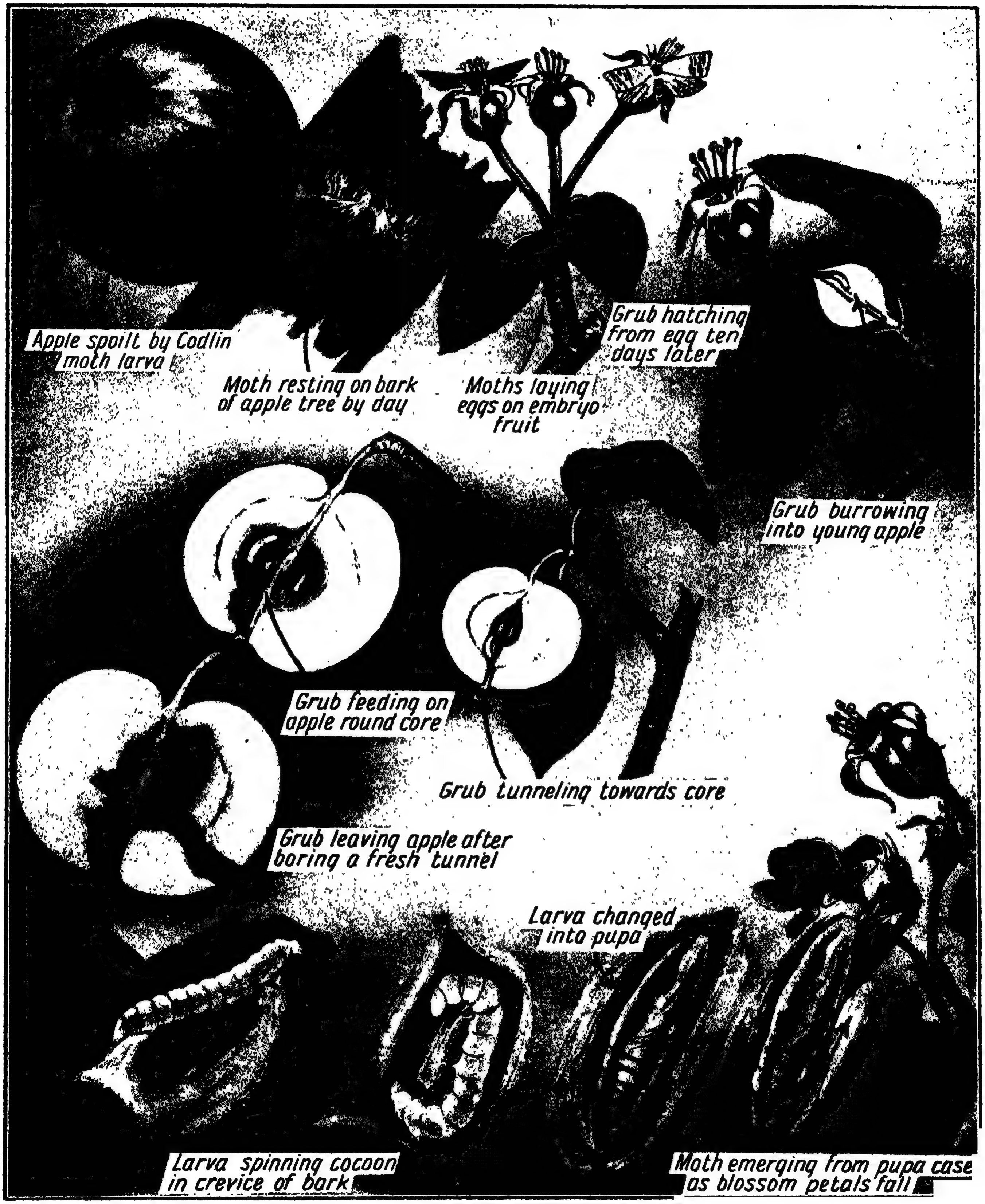
Emigrant Offspring

Another interesting thing, however, about the coconut, is that while it is so big as it hangs upon the tree, it is very light, and when it falls, as it often does, on to the beach and is washed into the sea, it does not sink, but floats and is often carried away to start its life like an emigrant in some new land overseas. That is why many isolated coral islands are covered with coco nut palms, the only plant growing on their lonely area. The coconuts floated across from other lands and then sprouted and grew.

When it is full-grown and bearing fruit, a healthy palm will produce 120 coconuts every season, and a small clump of trees is therefore sufficient to maintain a family in comfort.

Let us all remember what we ourselves owe to the coconut when we wash our hands with soap, when we put glycerine on our chapped skin, or when we eat the margarine spread on our bread in place of butter by some frugal boarding-house landlady.

THE LIFE STORY OF A GREAT PEST



The worm-holes we often see in apples are caused by the codlin moth larva, which is the most destructive of all apple pests. The greyish-brown moth flies at dusk, and by day rests on the bark of the tree. When the apple blossom is turning into fruit the female moth lays from 60 to 75 eggs on the embryo fruits. About ten days later the eggs hatch out, and each young grub burrows into the fruit As the fruit grows the grub feeds on the apple round the core, and later leaves the fruit by a fresh tunnel. The larva now spins a cocoon and spends the winter in crevices of the bark. Then when the apple tree blossoms it changes into a pupa, and later becomes a moth

HOW THE VOICE-BOX HELPS US TO SPEAK

Breathing is one of the most important things that our bodies do regularly. If we did not change the air in our lungs by alternately breathing in oxygen and breathing out carbon-dioxide, we should not live very long.

Breathing also helps our sense of smell, for it is as the breath is taken in through the nose that particles of matter are also taken in and affect certain nerves, giving the sensation of smell. Again, breathing helps our hearing, for on each side of the head is a little tube called the Eustachian Tube, connecting the ear with the pharynx, and it is by means of breathing that this tube is able to keep the air under the eardrum at the right pressure.

But after the supply of oxygen to our lungs, perhaps the most important function of breathing is the production of voice and speech. It is by drawing in and passing out air that we are able to make sounds and talk to one another. Without voice and speech it would be exceedingly difficult for us to share our thoughts and knowledge with one another, and make our wishes known. We know how difficult this is if we have ever watched two deaf mutes talking to one another on their hands.

It is the upper part of the windpipe, known as the larynx, which is the voice-box, helping us to produce sounds. Inside the larynx is a delicate skin connected with the lining of the windpipe, and at one place this forms two flaps, one on each side. These can be brought together so as to leave only a narrow chink, for the purpose of voice making, or they can be separated, leaving a wider opening for the passing of air when we are not speaking.

The flaps are called vocal cords, and not only can their position be changed, but they can be stretched tight or left loose. When they are close together with only a small chink between them the passage of the air through the opening causes them to vibrate, and this sets up sound-waves, which pass through our lips. The pitch of the voice depends upon the tightness with which the vocal cords are stretched. When they are kept very tight the note is high.

When boys are about fourteen years of age, the larynx suddenly increases in size, and the vocal cords lengthen. It is this change in their throats which causes the voice to break. It is a great mistake to sing much when the change is going on, as the larynx may be permanently spoilt through overwork in its delicate condition.

Good speaking and singing depend upon the size and shape of the openings of the mouth and pharynx. To a large extent these are under our own control, and so we can be taught in most cases to speak and sing well. Even deaf mutes who cannot hear a sound can now be taught to use their mouths and throats so as to speak.

It is the alteration of the shape of the mouth which makes the different vowel sounds, and we can see in the picture how the mouth changes when different vowels are being sounded. Consonant sounds are formed by using the lips and the tongue. It is an interesting exercise to say the letters of the alphabet very slowly and feel how the mouth, lips and tongue change.

The position of the throat and mouth when different vowels are being pronounced

THE WAY IN WHICH A LIVING SPONGE TAKES A MEAL

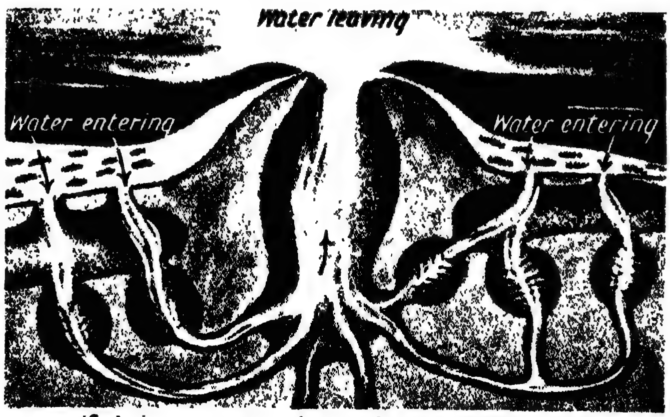
When we use a sponge in the bath we rarely realise that we are using the skeleton of an animal, or rather of a colony of animals. The sponge of our toilet is the horny skeleton made by a number of little animals that live in the sea, although perhaps it looks more like a plant, and indeed many people seem to think that the sponge is a plant.

The bath sponge consists of a complicated network of horny fibres and their composition, chemists tell us, closely resembles that of the silk of the silkworm.

Of course, the sponge, as we use it, is the dead skeleton, but when it is growing in the sea the animals occupy its openings and chambers much in the same way as human beings occupy a block of flats or a large hotel.

The sponge animals gather their food from the sea, and they obtain it by drawing water in through small pores and ejecting it after the fluid has passed through their interior canals by the larger openings which we see in our sponges. As the water goes through the horny skeleton or home the food is seized by the living animals.

The food consists of very minute plants and animals, and these are seized and digested by the cells of the sponge, which are furnished with cilia, or very fine hairlike vibrating organs. The word "cilia" is a Latin word meaning "eyelashes."



A magnified piece of sponge, showing how the sea water is drawn in through small openings and thrown out through a large opening. During its passage minute animals and plants are seized and digested

A QUEER THING ABOUT BOILING WATER

If you went to La Paz, the capital of Bolivia, which stands over two miles above the level of the sea, you would not find it easy to cook potatoes by boiling them. They might be over a fire for hours, but the water would not get hot enough to cook them properly. What is the explanation of this curious fact? Well, it is the strange behaviour of water when it is boiled high up in the mountains, as is described on this page.

When scientists speak of the boiling point of water they mean that water will boil at sea level when it reaches a temperature of 100 degrees Centigrade; and sea level is defined as that condition of the atmosphere when the barometer is standing at what is average pressure, that is, 29·9 inches. In other words, the boiling point of water is 100 degrees Centrigrade at sea level with the barometer at 29·9 inches.

There are two scales for measuring temperature, the Fahrenheit and the Centigrade. Most domestic thermometers are marked in the Fahrenheit scale, but for accurate scientific work the Centigrade scale is used, as in this article. It is a simple matter to convert one scale to another. Thus, a reading in degrees Centigrade is converted to degrees Fahrenheit by multiplying the Centigrade reading by 9, dividing by 5 and adding 32 to the result; for example, 100 degrees Centigrade is equal to 212 degrees Fahrenheit. Degrees Fahrenheit are converted to degrees Centigrade by subtracting 32 from the Fahrenheit reading, multiplying by 5 and dividing by 9.

Pressure and Heat

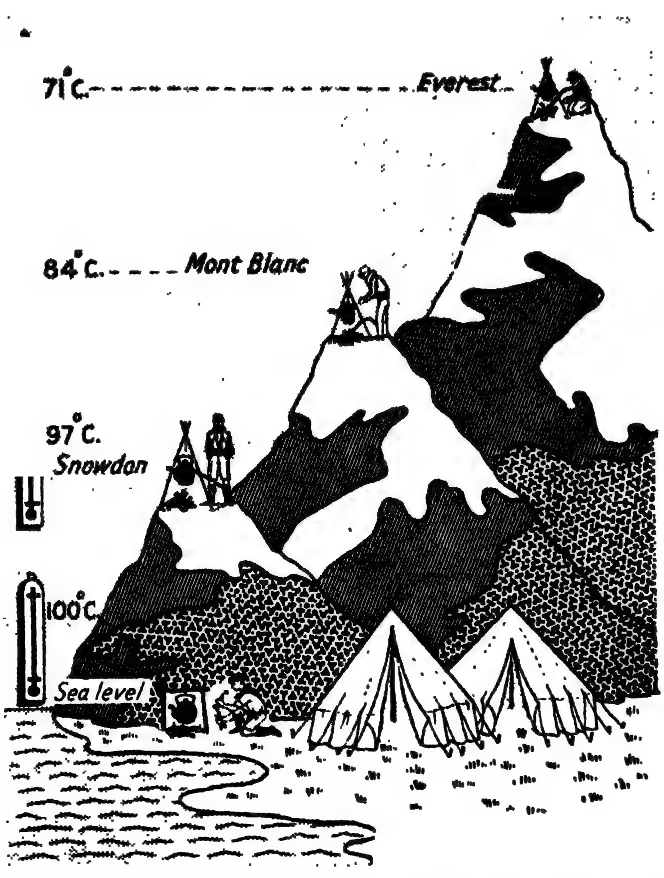
But whatever the scale used, the boiling point of water is governed by the barometer reading, and will always be 100 degrees Centigrade at a barometer pressure of 29·9 inches. On the other hand, the barometer reading varies with the air pressure, and as air pressure becomes less as we rise above sea level, it follows that the boiling point of water falls the greater the height above sea level.

Why is such stress laid on sea level? The true reason is that the higher we go the shorter is the column of air above us, and therefore the less its pressure. This must be clear to everyone, for while at the bottom of the atmosphere we are pressed down by all the air above us; at a height of, say, a thousand feet, we are pressed by only the air above that level, and so on. The air gets thinner and thinner as we go higher up, and though it is believed to extend for some hundreds of miles above the Earth's surface, one half of its weight lies within a little more than 3½ miles of sea level.

At the top of Mount Everest nearly three-quarters of the atmosphere's weight lies below that level. Obviously, then, as we go up a mountain the pressure gets less and less and water boils at a lower and lower temperature. At the top of Mount Snowdon, for example, which is about 3,560 feet high, we could boil our kettle at just under 97 degrees Centigrade. On Mont Blanc the water would boil at about 84 degrees Centigrade. At the top of Mount Everest, the highest mountain in the world, which is 29,002 feet high, water would boil at 71 degrees Centigrade. This means that at these high levels water, when it boils, is much less hot than it is in the lowlands, and it is therefore much more difficult to cook by boiling at a high altitude.

At La Paz, for example, in Bolivia, which lies nearly 12,000 feet above sea level, the boiling point of water is about 90 degrees Centigrade, and it is very difficult indeed to cook potatoes there, the heat of the boiling water being hardly sufficient for the purpose.

Now all this is very interesting, but how does the question of water boiling at different temperatures according to the pressure of the atmosphere, affect us in our own homes? Although we probably never think of it, the boiling point of water in our kitchen is constantly changing with changes in the reading of the barometer. A difference of one inch above or below the standard reading, which is 29·9 inches, raises or lowers the boiling point by 0·5 of a degree Centigrade, and so the housewife when she boils the potatoes finds it more difficult to cook them if the barometer is low.



Water boils at a lower temperature the higher we go, as we can see in this picture diagram of the boiling point of water at various heights. This means that boiling water is much hotter at sea level than it is high up on a tall mountain

Watching the Barometer

For instance, at or near sea level, with the barometer reading 29 inches, the temperature of boiling water is only about 99·5 degrees Centigrade, or half a degree cooler than when the barometer is at the standard reading of 29·9 inches. On the other hand, if the barometer reads 30·8 inches, as it often does, the temperature of boiling water is about 100·5 degrees Centigrade.

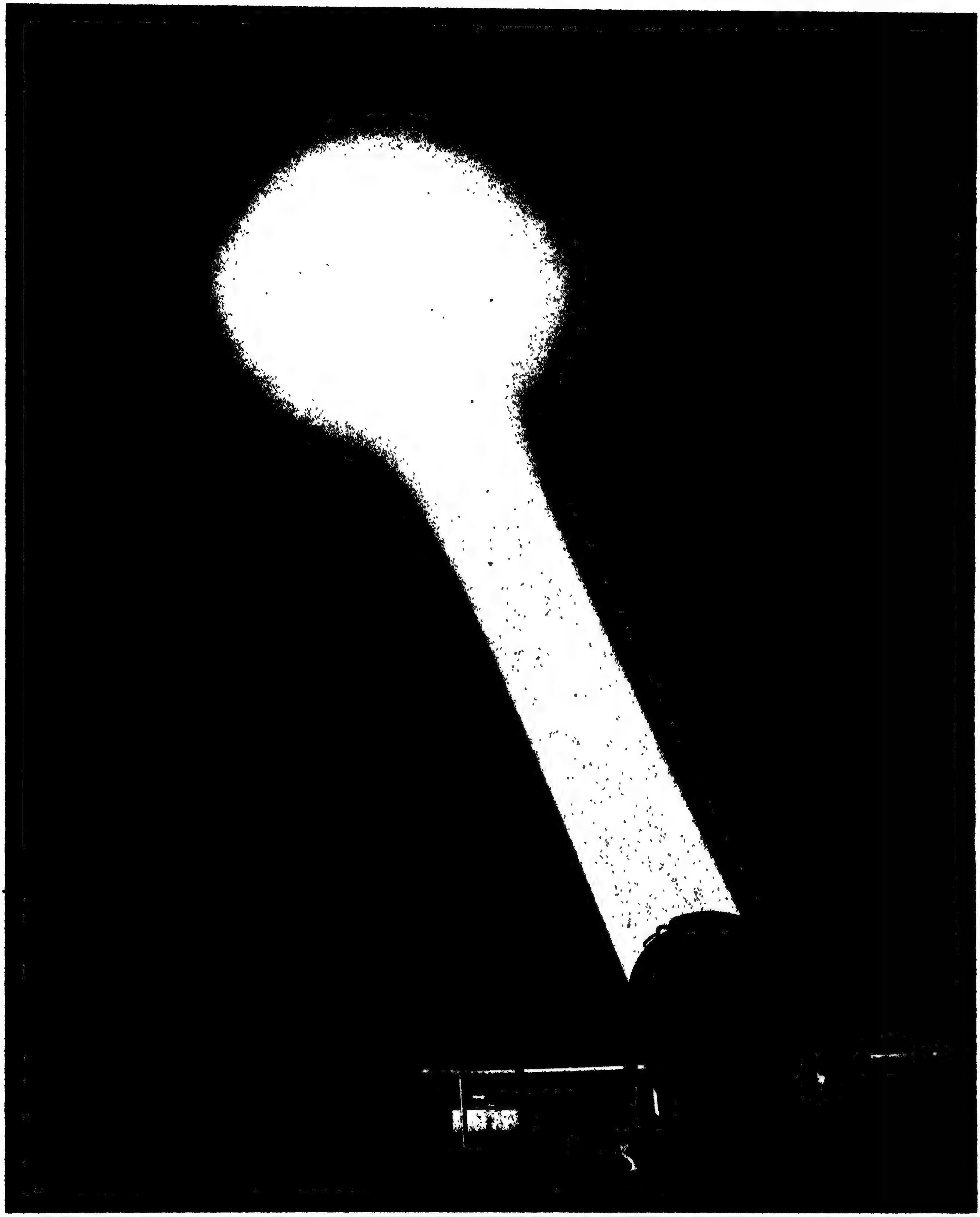
Of course, in boiling food a degree or two does not matter very much, but in carrying out elaborate experiments scientists have to take into consideration the pressure of the atmosphere at any given time.

Although water boils only at high temperatures, evaporation is going on at all times.

WHAT HAPPENS WHEN WE SING A SONG

Have you ever wondered what happens exactly when you sing a song? If you have a good singing voice it all seems so simple. You read the music and then by singing the correct notes produce the tune. But actually all kinds of wonderful things take place in your brain and body when you are singing, and this picture-diagram will help us to understand the various processes. First of all, rays of light from the notes and words of the music pass to your eye, enter through the pupil and, striking on the retina or curtain at the back, send a message to the lower eye centre of the brain. This is where the form of the note is recognised. From there a message is carried to the higher eye centre, which realises what the note means and a message is passed on to the association centre and then to the motor centre, which in its turn sends a message to the diaphragm telling it to work, to the larynx to move the vocal cords, and to the lips and tongue to get into the right position to produce the words and notes. The sounds set up waves in the air which enter the ear and strike on the drum, sending a message to the lower ear centre, where the sounds are heard. From there the message goes to the higher ear centre, which has to do with recognising tone and pitch and volume of sound. From there the message passes to the association centre where what is seen on the music book and what is heard and the instructions to diaphragm, larynx, tongue and lips are all linked harmoniously together. We must always remember that it is not the eye that sees or the ear that hears, but the mind of man

A LIGHT OF 160,000,000 CANDLE-POWER



Searchlights are used by ships to light up difficult channels when navigating at night, but until the development of radar their principal use was in warfare to illuminate enemy aircraft so that artillery could sight them at night. The light is obtained by striking an electric arc between two carbon rods, and the light is reflected outwards by a parabolic mirror set in the back of the searchlight barrel. The largest searchlights, as in the above photograph, project a beam of light equal to 160,000,000 candle-power, visible from a distance of 150 miles. Searchlights projecting a vertical beam into the sky are sometimes used as marker beacons at airports

EXPERIMENTS WITH A LIGHTED CANDLE

There are many interesting experiments we can carry out with a lighted candle, and from which we can learn a great deal of science Michael Faraday, the brilliant discoverer, once lectured on the candle at the Royal Institution, and he published a book on the chemical history of a

How we can blow a flame towards us

candle We are therefore following in good steps when we try to learn some science from a lighted candle.

A very interesting and amusing experiment is that of putting out a candle by blowing through a funnel on the flame We can use either the ordinary tin or aluminium funnel that is found in most kitchens, or we can make a funnel for ourselves by rolling up a sheet of fairly stiff paper into a cornet and cutting off the point to make a mouthpiece, pinning the paper together to prevent it from unrolling.

We ask a friend if he can put out the candle by blowing through the funnel, and of course he says "Yes." We hand him the funnel, and in ninety-nine cases out of a hundred he will hold the funnel as shown in the first picture, putting the wide part to the candle

The way to hold a funnel when blowing out a candle-flame

flame and blowing through the spout.

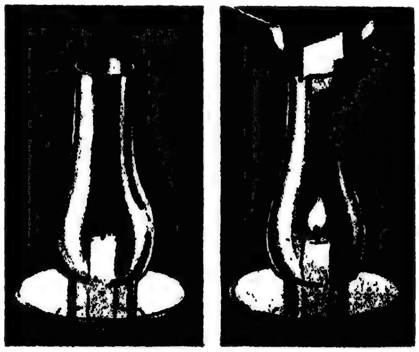
But instead of the candle flame being extinguished a strange thing happens. The flame turns in the direction of the funnel, that is, the flame is blown towards the blower. The explanation is shown in the picture, where the arrows represent the air as it is blown and the direction it takes.

When we blow through the spout the air passes along the smooth, slanting sides of the funnel and goes round the flame, and air from outside passes towards the funnel to fill up the middle space. As it goes it directs the flame towards the funnel.

We can, however, put out the flame by blowing through the funnel if we do it in the manner shown in the second picture. We blow into the wide part of the funnel, and the air is then directed and concentrated so as to pass through the spout and out upon the flame.

Another interesting experiment in which the air plays a part can be performed with a candle and a lamp glass We stand a piece of candle in the middle of a saucer of water and light it. We then place over it an ordinary lamp glass, and before very long the candle begins to burn low and, if the glass is left in position, the flame goes out.

The reason for this is that the gas, oxygen, is necessary for combustion, and this oxygen is contained in the air. When the glass is put over the candle



How a candle goes out for lack of oxygen and how the supply can be kept up

all the oxygen inside is soon used up, as it combines with other substances during the combustion, and then the candle cannot burn When the flame is burning low, before it goes out, we can immediately revive it in a curious and interesting way

We cut a T-shaped piece of stout cardboard and place this in the top of the lamp glass, exactly midway in the opening, as shown in the picture. The flame at once begins to burn up again, because the lamp glass being now divided, the heated and used-up air passes up one side and cool fresh air from outside enters by the other opening and descends to the candle. The flame thus obtains a continued supply of oxygen and so can go on burning as though the glass were not over it. That the currents of air in the glass are in different directions on the two sides can be proved by holding a lighted taper at the top. In one case the taper's flame goes up and in the other case down.

Here is another good experiment which is quite easily performed. When a candle is burning steadily we can get a very striking effect by sprinkling slowly from our fingers on to the flame some lycopodium powder. This can be obtained at most chemists.

As the tiny grains of powder, which are really the spores of a fungus, come into the heat of the flame, they are burnt up, and we get an effect some-

A miniature lightning or firework effect

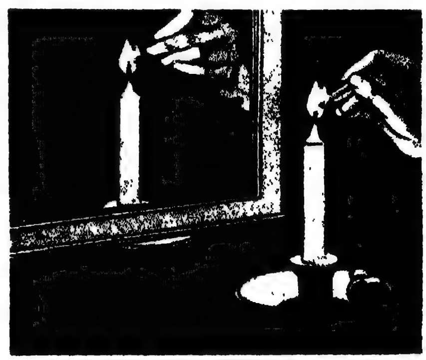
thing like miniature flashes of lightning, or the letting off of a firework.

When magnesium powder is used instead of the lycopodium powder the effect is still more brilliant and striking.

An interesting experiment in reflection can be carried out with a couple of candles and a pane of glass placed vertically between them. Each candle must be at exactly the same distance from the glass, one on one side and the other on the other.

We get in front of one of the candles and look into the glass in such a way that the reflected image of this candle exactly coincides with the actual candle on the other side of the glass. Of course, the two candles must be of the same height. We can soon, with a little adjustment, get the effect desired.

We then light the candle that is



An interesting experiment in producing a ghost flame

nearer to us, and at once it appears as if the candle behind the glass had also been lighted.

Of course, what happens is this: the reflection of the flame of the candle which we lighted is seen in the glass, and as it exactly coincides with the top of the unlighted candle, it appears like the flame of that candle.

HOW ARTICLES ARE ELECTRO-PLATED

This picture shows how the process of electro-plating articles is carried out. In a large trough made of a non-conducting substance like earthenware is placed a weak solution of cyanide of silver, and in it are hung plates of silver, suspended from positive electrodes, connected with an electric supply. The articles to be plated are hung in the solution from another rod, which is the negative electrode. A dynamo is set working and the current passes to the electrodes, being regulated by a resistance board and checked by a voltmeter. Silver from the solution is deposited evenly on the articles, while other silver from the plates is dissolved in the liquid, this keeping pace with the deposition of silver. The current is made stronger or weaker according to the length of resistance which it passes through

A QUEEN MEETS A ROBBER IN THE WOOD

After the battle of Hexham, Queen Margaret was a fugitive, and while fleeing through a forest with her little son she suddenly met an armed man of gigantic stature and stern aspect. The Queen told her story and, taking the little Prince of Wales by the hand, presented him, and said: "Here, my friend, save the son of your King." The man, who looked like an outlaw, was really a Lancastrian gentleman who had lost all in the Red Rose cause, and was hiding in the forest. He took the Queen and Prince to his den and supplied them with food and such comforts as were available. For two days the Queen remained in hiding, and then, after other thrilling adventures, she escaped to Scotland. This fine picture is from the painting by W. Christian Symons

THE STORY OF THE TWO ROSES

Everyone knows the Wars of the Roses by name, but many people are quite unaware of the causes that led to these wars, and of what happened in England while they were going on. Civil war is always a tragedy, and the Wars of the Roses were particularly so. The old chivalry of the Middle Ages disappeared, and men became cruel and selfish, caring for nothing except their own interests. Here we read the story of these wars and how they affected the whole life of the country

Civil war is always a terrible thing for a country, but there are times when a nation is divided on some question of principle, and both sides feel it right to fight for their cause. Such a civil war was that which took place in England in the time of Charles I, but which did little damage in the country as a whole.

But there has been one civil war in the history of England which devastated the country, which resulted in terrible bloodshed and the destruction of many valuable lives, but in which no question of principle was involved. It was a war in which the people themselves had no interest, but men had to fight and slay one another simply because the nobles, who then controlled the country, hated one another and were all struggling to get the upper hand.

This struggle, known to us as "the Wars of the Roses," lasted for thirty years, and although the waste of life and treasure was nothing but mad folly, and in the end neither side really triumphed over the other, the results of the war were stupendous.

The Nobles In Power

It changed the whole character of English life, and it marks a definite epoch in English history. Before the Wars of the Roses the great nobles were almost as powerful as the king; they had armies of their own, and did very much as they liked. The lives of the common people were absolutely in their keeping. Men had to work for their lords and fight for their lords, whether they liked it or not. And although a really strong and powerful king like Edward III or Henry V could keep control by playing off one powerful noble against another, yet he was very far from being able to do as he liked.

The Wars of the Roses changed all that. During those terrible thirty years a dozen fierce battles were fought, and either in battle or by treachery most of the powerful nobles were killed off by one another, so that at the end of the Wars of the Roses the King of England was left more powerful than he had ever been in history before. So great was the change that we usually say that the end of the Wars of the Roses was the beginning of Modern History.

When the powerful Henry V died he left a prince to succeed him, but the little Henry VI was only nine months old. Obviously he could not rule, and so the government fell into the hands of his uncles, the late king's brothers. One of these, the Duke of Bedford, became Regent of France, most of which then belonged to England; but the other, Humphrey, Duke of Gloucester, was a turbulent, ambitious and selfish prince, and unfortunately he had been appointed, by Henry V, Regent of England.

There was another very powerful and rich man, the uncle of Henry V, known as Cardinal Beaufort, and he and the Duke of Gloucester were continually quarrelling and striving for the mastery.

The scene in the Temple Gardens when the Yorkist and Lancastrian chiefs picked white and red roses as their badges. From the painting by John Pettie

In the early years of Henry VI's reign the English began to lose their conquests in France. It was the time when Joan of Arc did such marvellous exploits, and although she was afterwards captured and burnt at the stake, her work lasted. Never again did the English become masters of France.

If we want to get a vivid picture of the times of Henry VI and the Wars of the Roses, we should read the three parts of Shakespeare's play, "King Henry the Sixth." But we must not accept the facts from Shakespeare, for like many other playwrights, he used to alter his facts to suit his audience. The false and coarse description of the brave Joan, who is called La Pucelle, is a blot on the playwright's character. Not only so, but Henry VI's queen, Margaret, is slandered in this play, for whatever her faults, she was a woman of outstanding character, fearless, and of iron will.

The civil war came to be known as the Wars of the Roses, because the emblem of one party was a red rose and that of the other party a white rose. There is an old story that powerful members of both parties met one day in the Temple Gardens in London, and during a quarrel selected the roses as their emblems. The story is probably not true, but it is very interestingly put by Shakespeare.

Plucking the Roses

He makes one noble say:

> Let him that is a true-born gentleman,
> And stands upon the honour of his birth,
> If he suppose that I have pleaded truth,
> From off this brier pluck a white rose with me.

to which the reply of a rival noble is:

> Let him that is no coward nor no flatterer,
> But dare maintain the party of the truth,
> Pluck a red rose from off this thorn with me.

The roses were the emblems of two branches of the Royal Family, the Red Rose representing the House of Lancaster, and the White Rose representing the House of York.

Henry IV, the son of the powerful John of Gaunt, Duke of Lancaster was, of course, a usurper, but there was some justification for his usurpation, for owing to the misrule of Richard II, the Black Prince's son, some change of government was undoubtedly necessary. The next king, Henry IV's brave son, Henry V, dazzled the people of England by his victories abroad and by the time of Henry VI the people of England had quite settled down to the rule of the House of Lancaster.

When, however, Henry VI came of age and proved to be not a strong man of the same type as his father and grandfather, but a gentle soul, more suited for the monastery or the study than the throne, ambitious rivals saw a chance of seizing power.

Richard, Duke of York, was like Henry himself, a Plantagenet, for he was descended from Lionel, Duke of Clarence, the second son of Edward III. John of Gaunt had been the fourth son, and so the Duke of York considered that he had an even better right to the throne than Henry VI. His family was known as the House of York, and it was they who had the White Rose for their emblem.

All this may seem a little dry, but it is necessary if we are to understand how there came to be rival factions in England. Both sides were supported by powerful nobles, all of whom hoped to get wealth and power if only their side could get the upper hand.

In the terrible Wars of the Roses Henry was only a feeble-minded puppet. In fact, at several periods in the conflict he lost his reason altogether. There were, however, two outstanding characters without whom the Wars of the Roses would probably have ended very much sooner.

A Lion Cub for a Bridal Gift

On the King's side there was his young wife, Margaret of Anjou, who had been married to him before she was fifteen years old. As a bridal gift she was presented, not with a lap-dog, as was often the custom in that day, but with a lion cub. It was a gift that seemed almost symbolic of what the character of the Queen was to be.

She was really a very wonderful woman, but her wisdom was not equal to her will, and she always seemed to have a knack of selecting the wrong people to advise her, or to carry out her orders. Such iron determination, however, as she showed has not often been seen in history.

Again and again, when the cause of the House of Lancaster seemed irretrievably lost and all the Lancastrian nobles despaired, Margaret, by sheer will-power, would raise a fresh army and sometimes herself appear in the field. Of course, it was bad for the country, but we cannot but admire her marvellous determination and energy.

On the other side, fighting for the House of York, was the Earl of Warwick, a man who has come down in history under the name of "Warwick the Kingmaker." It was really through his efforts that the House of York for a time triumphed over the House of Lancaster, so that its chief became King as Edward IV. But in the end Warwick changed sides, and for a time put Henry VI back on the throne. It is for this reason that he was given the title of the Kingmaker.

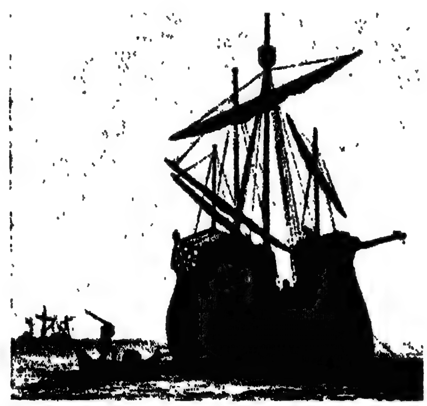
From the first coming of Margaret the English court became a centre of intrigue, rival nobles plotting against one another and against the Queen, and the Queen seeking to defeat her enemies.

The powerful Duke of Gloucester was put in prison, where he soon died. Of course, in those days when anyone died in prison the person who put him there was accused of his murder. This happened in the case of the Duke of Gloucester, and his death was believed to have been ordered by his enemies, Cardinal Beaufort and another friend of Margaret's, the Duke of Suffolk, the Queen herself also being suspected.

Execution on the High Seas

The Duke of York had been sent to govern Ireland, so as to be out of the way, but his relatives, the Earl of Salisbury and the powerful Earl of Warwick, then arrested the Duke of Suffolk. He would probably have been executed at once, but the Queen persuaded the King to banish him, and the Duke set sail in a vessel for France.

He was much hated, and 2,000 Londoners tried to intercept him on his discharge from the Tower. But he managed to escape to Ipswich, from which port he sailed for Calais.



The beheading of the Duke of Suffolk on a boat in the English Channel

When the ship was some way out at sea several other boats were seen approaching. One of these came alongside and ordered the Duke of Suffolk to come on board. As he went on to the ship he was greeted with the words, "Welcome, traitor!" Then the sailors conducted a mock trial, condemned him to death, and his head was chopped off and the body left on Dover sands.

London in the Hands of Rebels

Things were going from bad to worse for England. She lost every inch of territory in France except the town of Calais, and in England the men of Kent rose in rebellion, placing at their head an Irishman named Jack Cade, who professed to be Mortimer, Earl of March. He led 20,000 men to Blackheath very much as Wat Tyler had done seventy years before. But while Tyler's rebellion was a struggle of the people for social and personal freedom, that of Cade was a struggle for political freedom and the right to vote without interference.

Cade marched into London, where, striking the ancient monument known as London Stone with his sword, he cried: "Now is Mortimer lord of this city!"

The rebellion ran its course very much as Tyler's had done. At first the rebels behaved decently, then they began killing unpopular persons, and eventually started plundering and pillaging. By false promises they were persuaded to disperse, and Cade was then pursued and put to death. Shakespeare gives us in the second part of "King Henry the Sixth" a lively account of the doings of Cade and his followers in London.

It would be tedious to follow the course of the Wars of the Roses battle by battle. First one side won and then the other, but through it all powerful nobles were losing their lives and thousands of lesser people were shedding their blood for a cause for which they cared nothing.

The first battle was fought at St. Albans, when the Yorkists won. Henry's favourite, the Duke of Somerset, was killed, and the King himself was wounded in the neck with an arrow early in the fight. Man after man was killed, till at last the King was left alone under the Royal banner.

Madness in a Royal Brain

Then he walked away and went into a baker's shop close by, and there the Duke of York, the victor, visited him and, bending his knee, pretended to be loyal and bade Henry "Rejoice, for the traitor Somerset is slain." Henry replied: "For God's sake stop the slaughter of my subjects."

The Duke of York then took the wounded King by the hand and led him first to the shrine of St Alban, in the Abbey, and then to his apartments. The next day he carried him off to Westminster.

Margaret had remained at Greenwich with her ladies and her infant son. When this son had been born on St Edward's Day, in 1452, he had been named Edward, after the Confessor, and created Prince of Wales. His father, the King, however, was insane at the time, and fifteen months passed before he was able to take the least notice of his son.

The King's wound at the battle of St. Albans had been dangerous, and his insanity returned. So while the Duke of York and his party ruled the State, the King's person was handed over to the custody of his wife. Margaret was told to withdraw to the castle of Hertford, with the King and the infant Prince of Wales. She did so, and remained in seclusion for two years, when, the King having been restored to health, suddenly appeared in Parliament, taking every one by surprise, declared himself well enough to resume authority, and the Duke of York had to give way with the best grace that he could.

The new Duke of Somerset was placed in power, but again the King lost his health. When he recovered two years later he went to London and invited the Duke of York and his party to a great Reconciliation Banquet, with a religious service following at St. Paul's Cathedral. It was a great gesture of peace, and much was hoped from it. In the procession to the cathedral everyone walked with an enemy, the Queen taking the arm of the Duke of York, and all vowing eternal friendship at the altar.

The peace had lasted less than a year when a quarrel among some servants of the rival nobles set the whole conflict blazing once more.

Of all wars civil wars are the most terrible, and they seem to make men and even women more and more cruel as time goes on. Margaret, like all the great nobles, became very cruel and vindictive.

Brutal Deeds of Civil War

In a great battle at Northampton the Lancastrians were defeated and King Henry himself was captured. Margaret fled to Harlech Castle in Wales, and later, having gathered a fresh army, she met the Yorkists at Wakefield and defeated them. The Duke of York himself was slain, and his lifeless body, crowned in derision with a paper crown, was presented to Margaret.

She laughed and said, "Put the traitors' heads on York gate, and take care that room be left between the heads of York and Salisbury for those of the Earls of March and Warwick, which I intend shall keep them company."

One brutal deed resulting from this battle was done when the ruthless Lord Clifford, returning from the pursuit of the Yorkists, met the young Earl of Rutland, son of the Duke of York, on Wakefield Bridge. He was but a youth, and had gone with his tutor to see the battle. When Clifford rode up the young Earl fell on his knees and implored mercy by holding up his hands. "Spare him," said the tutor, "he is a prince's son, and may hereafter do you good."

"York's son!" exclaimed Clifford, eyeing the boy savagely, "by God's blood, thy father slew mine, and so will I thee and all thy kin." Then he plunged his dagger into the boy's heart and said to the tutor, "Go bear to his mother and his brother tidings of what you have heard and seen." England was indeed a terrible place to live in during those days.

The triumph of the House of Lancaster was short-lived. Several battles followed, in which Margaret's forces were defeated, and Edward, son of the dead Duke of York, was proclaimed King as Edward IV. Margaret and her son had to flee when her forces were routed at Hexham, and with a small party she escaped into Hexham Forest.

She had some of the Crown Jewels with her, and had not travelled far when her party was overtaken by a gang of robbers, who plundered them of everything of value. The bandits dragged the Queen with violent threats before their leader, held a drawn sword ready to cut her down, and threatened her with all sorts of indignities. She threw herself on her knees with clasped hands, weeping and begging for mercy.

A Queen's Adventures in the Forest

What would have happened we do not know, but at this point the robbers themselves began to quarrel about the spoil, and while they were fighting Margaret with her son managed to escape farther into the forest.

Such places at that time were infested with desperadoes, and we are told that Margaret was in frightful peril and fancied every tree she saw was a man with a naked sword in his hand. Neither she nor her boy had tasted food for twenty-four hours, and while they were wandering, not knowing at this time whether the King was alive or dead, they suddenly saw before them, by the light of the moon, an armed man of gigantic stature and stern aspect, advancing towards them with threatening gestures.

Jack Cade, the rebel, ordering Lord Saye and Sele to be beheaded as described by Shakespeare in King Henry the Sixth, part 2. From the painting by Charles Lucy

A Friend in Need

At first Margaret thought he was one of the gang of ruffians which had robbed her, but she did not lose courage. She called the man and told him her story, taking the little Prince by the hand and presenting him to the outlaw with these words: "Here, my friend, save the son of your King."

It turned out that the man was a Lancastrian gentleman who had lost all in the Red Rose cause, and had long been hiding in the forest. He led the Queen and Prince to his den, where his wife furnished the fugitives with food and gave them such comforts as were available. For two days the Queen remained in hiding, and then escaped to Scotland.

Afterwards she went across to Burgundy, where the Duke, whom she had once threatened to hang if he fell into her power, treated her well. Then Warwick the Kingmaker, having been slighted by Edward IV, went across and saw her, and offered to fight for her cause.

He returned to England, gathered an army, and defeated Edward IV, who had to flee. Henry VI, who had been kept a prisoner in the Tower, was released, but again the victory was short-lived. Two other battles were fought, one at Barnet, at which the Kingmaker was slain, and one at Tewkesbury, where the Lancastrian cause was finally lost. Henry VI, Margaret and the Young Prince of Wales were captured.

The Red Rose Crushed

When the brave young Prince was brought into the presence of Edward IV that monarch asked, "What brought thee to England, and how durst thou enter into this our realm with banner displayed?"

"To recover my father's rights," answered the heir of Lancaster, and then he added fearlessly, though not wisely, "How darest thou, who art his subject, so presumptuously display thy colours against thy liege lord?"

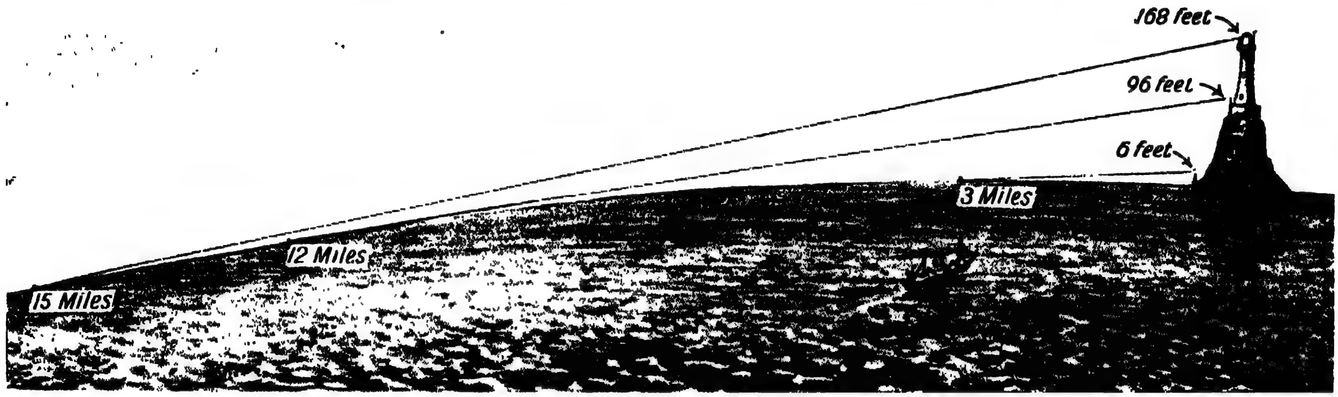
Edward was furious and savagely struck the unarmed Prince in the mouth with his gauntlet. Thereupon it is said the Dukes of Clarence and Gloucester rushed upon the youth with their swords and slew him.

Henry was taken to the Tower of London, where a day or two later he died or else, perhaps was murdered. Margaret was also placed in the Tower, and kept a close prisoner, but later she was ransomed by King Louis XI of France, and returned to that country, where she remained till her death. It was certainly true in the days of the Wars of the Roses that "uneasy lies the head that wears a crown."

But from the Wars emerged a new England. The old independent nobility was destroyed and a new nobility arose, dependent for its creation and existence on the King. The Church became weakened and was unable to resist the Crown, while, on the other hand, the commercial classes and the towns steadily increased in power and influence. The people, who had tasted the full horrors of civil war, were glad to have a strong king to preserve peace.

THREE THINGS THAT PROVE THE EARTH IS CURVED

This picture shows an experiment which has been carried out by scientists on several occasions. It is one of the proofs that the Earth's surface is curved. Three posts are placed in line along a calm stretch of water, such as a canal, each post being exactly the same height above the surface of the water, then a sight is taken along the posts, looking from the first one to the third. The middle post always appears higher than the others, because the Earth's surface is curved. If the tops of the first and second posts are seen in line, then the third post appears lower for the same reason. Sometimes instead of the posts being fixed in the canal bed they are placed on floats



Here is another proof that the Earth's surface is curved. The horizon on an open plain or at sea always appears as a circle, and the higher we are from the ground at sea-level the wider in diameter does this circle become. For example, when we are six feet above sea-level the horizon is three miles away. If we go to the top of a hill of say, 96 feet, we can see twelve miles, and so on. This could not possibly happen unless the world on which we live had a spherical surface

The most familiar proof that the Earth's surface is curved is that of the ships that disappear below the horizon. First the hull goes, then the funnels and masts, and finally the smoke. This would not be the case if the Earth's surface were flat, for then the bulkier parts of the ship would remain in view longest, the hull being seen long after the masts had disappeared. It is interesting to stand on the beach and watch the hull of a ship disappear below the horizon, and then to go to the top of the cliff, when we can again see the hull. Of ships coming to shore we see first the smoke, then the masts, then the funnels, and finally the hulls

HOW WE KNOW THE EARTH IS ROUND

Most of us take it for granted that the Earth is round in shape, like a ball or orange. But how do we know this? Perhaps the best evidence is that the shadow cast by the Earth on the Moon is always circular, but there are many other proofs that the Earth's surface is curved, and it is by putting all the various evidences together that men have discovered that the Earth is spherical in shape

It is not surprising that the men of olden times thought the Earth was flat. It certainly has the appearance of being so. In any flat district we see the Earth spread round us as a flat disc stretching away in all directions to a circular rim. Every day the Sun rises over the eastern edge and passing across the arch of the sky vanishes below the edge on the other side, and even if we climb up a hill we get the same appearance.

Up to rather more than 2,000 years ago, therefore, men regarded the Earth as a great plain broken only by hills and mountains and bounded by the sea.

The Dawn of a New Idea

But rather more than 500 years Before Christ certain Greek philosophers began to get a true idea of the real form of the Earth. Some of them noticed that in travelling north or south new groups of stars came into sight over the horizon, and they therefore came to the conclusion that the Earth's surface could not be flat but must be convex or rounded, otherwise this could not happen.

Then that great philosopher Aristotle, who was teaching about the middle of the fourth century B.C., noticed that the Earth's shadow, falling on the Moon during an eclipse, was curved, and from this he argued that the Earth must be a sphere, or ball.

Still later, somewhere about the beginning of the Christian Era, another thing was noticed, and this was that when ships went out to sea the lower part of the ship disappeared before the upper part, as though the vessel were travelling round a curved surface. It is perhaps curious that this proof of the curving of the Earth's surface was not noticed even earlier. Perhaps it may have been, although there is no very early record.

Our Earth Resembles an Orange

From that time to this other proofs have been found that the Earth is not a flat surface but is curved, and by putting the various proofs together we find that it is not only curved, but that it is practically a big ball. Careful measurements have shown, however, that it is not exactly a sphere, but what is known as an oblate spheroid. "Spheroid" simply means "sphere-like," or not quite a sphere, while "oblate" means "flattened at the poles."

So the Earth is really shaped something like an orange, and it is also like an orange in another way. Its surface is not smooth like that of a glass ball, but rough like that of an orange, though in proportion to its size the roughness of the Earth is much less than the roughness of an orange.

Proving that the World is Round

Now let us see the various reasons for believing that the Earth is round. Any boy or girl at the seaside can carry out the simple experiment of watching a ship going farther and farther out to sea. If the Earth were flat the more slender parts, such as the masts and funnels, would disappear first from view, and the more solid and massive part—the hull—would be seen last. But the reverse is the truth. First the hull sinks below the horizon, then the funnels, then the masts, and then the smoke.

One evidence that the Earth is like a ball in shape is the fact that a ship can start out and sail right round the world, returning to the same spot, travelling all the time roughly in the same direction

If we are watching a ship from the beach and see it disappear in this way, if we hurry up on to the top of the cliff we shall see the ship once again, because being higher up we can see farther round the Earth's curved surface.

It is the same when ships are coming from the sea to land. A sailor going to the top of the mast sees from that position land or other ships invisible to those on deck. An old sea song mentions this in the lines:

> The sailor sighs as sinks his native shore,
> And climbs the mast to feast his eyes once more.

Another reason for supposing that the Earth is round is that a ship starting off from any port and keeping its prow turned constantly in the same general direction will, after a long voyage, return to the place from which it started.

The Horizon is Always a Circle

Then the fact that the sunrise takes place later or earlier as we travel west or east is a proof that the Earth's surface is not flat, for if it were so the Sun would rise at the same time at all places on the Earth.

There is also the fact that from wherever we stand the horizon at sea or on an open plain is always a circle, and the higher we go up from the ground the greater does the circle become. When our eyes are five feet above the level of the sea the horizon is about three miles distant. It varies a little according to the state of the atmosphere, which affects the rays of light.

An airman going up to a height of 13,000 feet would still see a circular horizon, and the area covered by his vision would be about equal to that part of our island which includes the whole of England and Wales.

An Experiment with Three Posts

There is an experiment which men of science have carried out which proves clearly in another way that the Earth's surface is curved, and how much it is curved. They place three posts in a line along a level stretch of water such as a canal or calm lake, fixing the posts just one mile apart and with exactly the same length of stake above the water in each case. When they look with a telescope from the top of the first post to the top of the last post, the top of the middle post appears above the line of sight between the others.

When the posts are a mile apart the top of the middle post is eight inches above the line of sight between the others, showing that the water's surface is curved to the extent of eight inches in a mile. In two miles the curvature is 32 inches, and in three miles 72 inches.

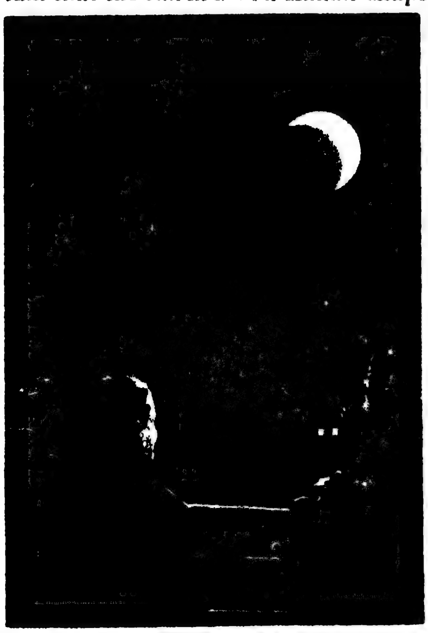
As a matter of fact, in digging railway cuttings and canals the engineers always make an allowance of eight inches per mile for the dip due to the curvature of the Earth's surface.

These facts that have been given all prove that the Earth's surface is curved, but they do not prove that the Earth is a ball or sphere. It might be shaped like a cylinder or a Rugby football, or a pear or an egg, and still give these results.

Aristotle's reasoning, however, shows that the Earth is a sphere or nearly so, for when it comes between the Sun and the Moon and its shadow is thrown upon the Moon, no matter what position the Earth may be in, the shadow cast is always that which would be cast by a sphere.

Photograph showing the curvature of the Earth. It was taken from a rocket at an altitude of 100 miles. Distance from the curved horizon at top of picture to bottom of picture is about 900 miles. Dark patch below horizon is the Gulf of California

We may carry our reasoning still further and say that seeing that the other members of the Solar System are spheres or almost spheres, it is pretty certain that the Earth is of a similar shape.



The shadow cast by the Earth in an eclipse of the Moon is always circular, no matter what position the Earth may be in

Another proof of the round shape of the Earth is provided by the position of the stars overhead at different places. If the surface of the Earth were flat the position of any particular star such as the Pole Star would be the same from whatever place it was viewed, as the stars are so distant that to travel horizontally for many thousands of miles would make not the slightest difference in their apparent positions.

But as we travel northwards the altitude of the Pole Star gets greater and greater until at the North Pole it is overhead, while if we go in the opposite direction it gets less and less until at the Equator it appears on the horizon. The difference is 90 degrees, and it is clear, therefore, that a traveller passing from the North Pole to the Equator would have travelled through a quarter of a circle, for a circle is divided into 360 degrees. This is a proof that the Earth is convex in a north and south direction.

It seems strange that at this date there should still be some people in civilised countries who refuse to believe that the Earth is a sphere and maintain that it is a flat surface. They are very strong in their opinions, and have published books on the subject.

They call this kind of teaching Zetetic Astronomy, the word zetetic being derived from the Greek word zeteo, which means to search or examine. But, of course, the discovery of the Earth's true spherical shape has been arrived at entirely by zetetic methods, that is by testing and examination.

Not so many years ago an illustrated book was published with diagrams showing that the North Pole was the centre of a flat, circular Earth, the southern regions being the circumference. The writer declared, " that the south is an immense ring or glacial boundary is evident from the fact that within the Antarctic Circle the most experienced, scientific, and daring navigators have failed in their attempts to sail in a direct manner completely round it."

Of course, later exploration proved this to be nonsense, and the more we know of the Earth the more we are convinced that it is shaped like an orange.

But, of course, it is important not to pretend that certain proofs of its curvature are proofs of its spherical shape. The Earth could be curved yet not be shaped like a ball.

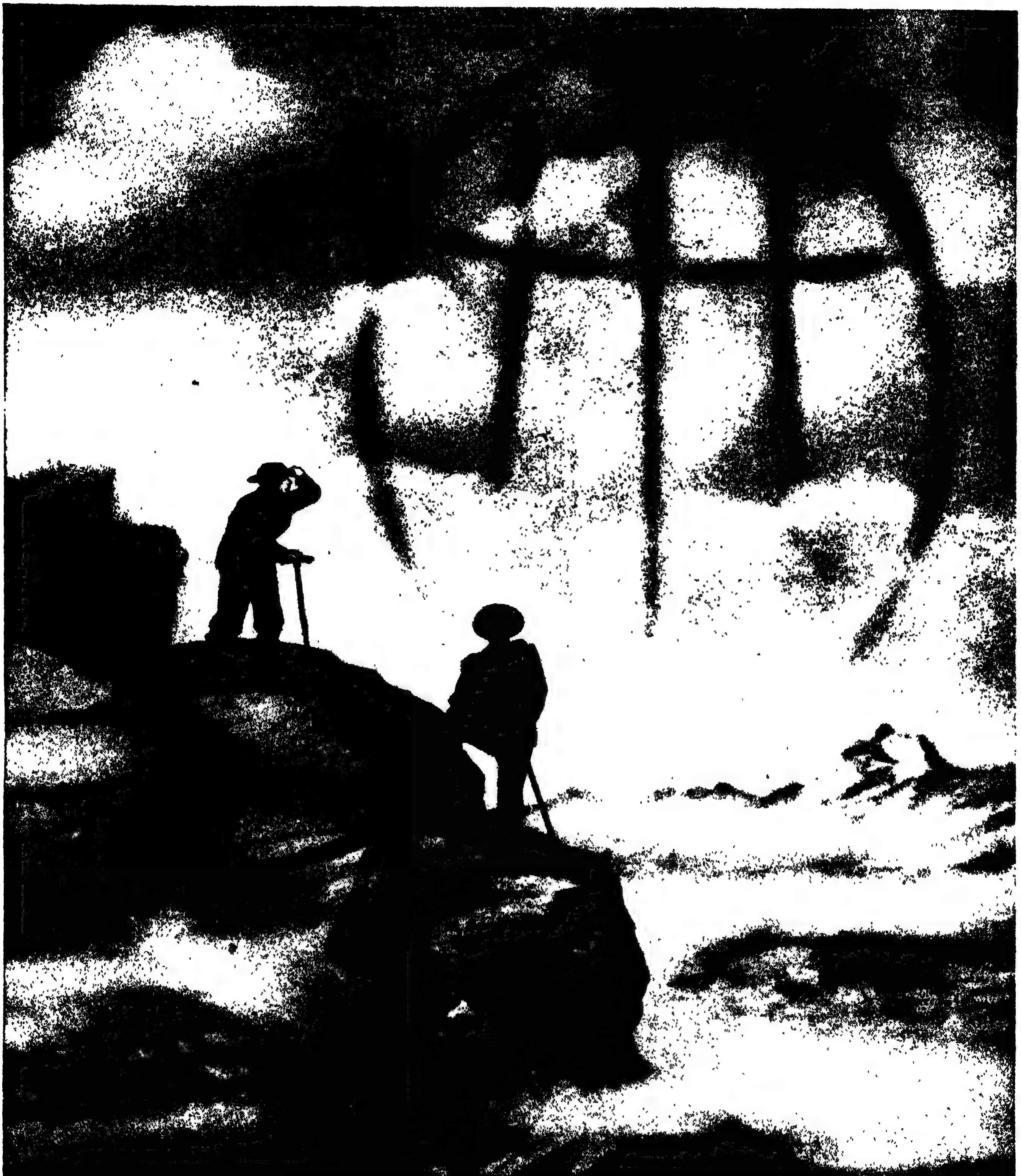
The curvature of the Earth was clearly indicated on a photograph taken from a V2 rocket launched from New Mexico, U.S.A., to an altitude of 100 miles. The photograph, reproduced on this page, shows an area of more than 200,000 square miles of land and water.

Owing to the Earth's spherical shape, as we travel round its surface fresh stars are constantly coming into view

A REGULAR SUPPLY OF HOT WATER

In some parts of the world there are hot springs from which boiling water and steam are spurted out from time to time. These springs are called geysers, an Icelandic word meaning something that is violently expelled. It is really the same word as our English word "gusher." There are geysers in Iceland, New Zealand, and the Yellowstone National Park in the United States. Some geysers send up a column of boiling water and steam for 200 feet or more. The one shown here, which is in the Yellowstone Park, is named "Old Faithful," because it is so regular in its action. For years it has sent up its stream of boiling water and steam to a height of from 120 to 170 feet every 65 seconds, but recently it has shown a tendency to be rather less regular. It is believed that surface water enters the tube of the geyser and when it reaches the walls of hot rock low down it is brought to boiling-point, and the sudden expansion into steam forces out the water above. Other geysers send up only a small column of water every few minutes to a height of only two or three feet, while others erupt very irregularly indeed and some have become quite extinct in living memory

A STRANGE APPARITION IN THE ALPS



A strange sight is sometimes seen by travellers in the Alps. It has been described by Mr. Edward Whymper, who first climbed the Matterhorn. A mighty arch appears high in the sky, when the Sun is behind the traveller's back. The arch gradually becomes a circle or an ellipse with a line down the middle, and then two faint crosses appear on either side. At the time of such an appearance there is a mist or fog, and the apparition is thrown upon the bank of fog. This appearance, which Mr. Whymper and other travellers call a fog bow, is not the same thing as we know as a fog bow in England. That is a kind of white rainbow, and is described in another part of this book. The Alpine phenomenon is more in the nature of the Spectre of the Brocken, in which gigantic images of travellers and other objects are thrown upon a bank of fog. The exact way in which these strange appearances in mountain regions are caused is not definitely known, but they are, of course, due to the refraction and reflection of light. This Alpine fog bow is rather awe-inspiring. Mr. Whymper says : "It was a fearful and wonderful sight, impressive beyond description"

MARVELS of MACHINERY

THE SECRET OF THE LIFEBOAT'S SAFETY

What would seamen do nowadays without the lifeboat? Although the lifeboat is less than 150 years old, over 63,000 lives have been saved round the British coasts alone by lifeboats of the Royal National Lifeboat Institution, which was not founded till March 1824. The modern motor lifeboat is very different from the early rowing and sailing boats, and is a costly, though very efficient, machine. As fast as funds will allow motor-boats are replacing the older type. Here we read something of the romantic story of the lifeboat

The lifeboat is the safest craft that can ride the rough seas, and so rarely is a lifeboat upset that when such a disaster happens it creates quite a sensation, and the newspapers are full of the story.

Why is it that a lifeboat does not upset as easily as an ordinary boat? Well, it is all due to the peculiar construction of the lifeboat. In the first place, it is much broader built than an ordinary rowing-boat, and this makes it far more difficult to upset. We all know how anything with a broad base is much more stable and much less likely to be overturned than something with a narrow base. We read about this on Pages 33 and 34.

Then in the second place, the lifeboat is fitted with a number of air chambers and other devices which make her exceedingly buoyant, so that she rides more easily over the high waves. Further, she has a number of self-acting, non-return valves, which enable her to discharge in a few moments any quantity of water that may be washed into her as she makes her way over the sea.

The Boat that Rights Itself

The construction of the lifeboat has been brought almost to perfection in these days, and for a boat to capsize is so rare that in many cases she is not built with any special idea of causing her to right herself should she really come to be capsized.

There are, however, lifeboats known as self-righters, which if they are turned over by some terrific wave will in a moment or two return to their proper position.

This is brought about by having air-cases set high at the head and stern, which are capable of bearing the whole weight of the boat if she is placed in the water keel uppermost. In this position she floats unsteadily on the two air-cases with the keel and ballast above the centre of gravity.

The consequence is that this weight cannot possibly remain in such a position for more than a moment or two, and the boat falls over on her side and then takes up her proper position, while any water which may have washed in escapes through the relieving or non-return valves. These are made of gun-metal and open downwards only, so that they at once yield to any pressure of water upon them.

Englishmen should be proud to know that the lifeboat owes its invention to three of their countrymen, Lionel Lukin, William Wouldhave, and Henry Greathead. The first lifeboat and the first lifeboat station ever seen in the world were established at Bamborough Castle on the Northumberland coast in 1786, and the first Lifeboat Institution for saving life at sea was founded by an Englishman in England.

The idea of making a boat which could not be submerged first came to Lionel Lukin, a London coachbuilder, who, though a landsman, had sea blood in his veins, for he was descended from one of Admiral Blake's captains.

He bought a Norway yawl and fitted her with projecting gunwales of cork, and air compartments running from stem to stern inside, and two larger air-boxes, one at the head and the other at the stern. Then he gave the boat a heavy iron keel to ballast her. The boat was a great success, but Lukin's idea was not to establish a lifeboat service round the coast, but to have all boats made so seaworthy on the principle described that there would be no need of a lifeboat service.

The self-righting lifeboat was invented as the result of an accident. William Wouldhave, a house-painter of South Shields, noticed that a piece of broken wooden bowl in a bucket of water always righted itself when turned upside down, and he built a lifeboat on the same principle. His model is shown on the next page

The First Lifeboat

Lukin took out a patent for his lifeboat, but nobody was very interested, except Archdeacon Sharp, the vicar of Bamborough, who was a trustee for charitable funds left by a Bishop of Durham. He thought Lukin's lifeboat such a good idea that he ordered one, and this in 1786 was established at Bamborough, which thus became the first life-saving station in the world. That earliest lifeboat was the means of saving very many lives.

The second Englishman to whom we owe the lifeboat, William Wouldhave, was a house-painter of South Shields, who in his spare time taught singing to charity children and acted as parish clerk. He had the idea of making a boat that would neither sink, nor, if it were capsized, remain upset. The latter idea was the result of an accident.

He was walking in the country one day when a woman asked him to help her in lifting a heavy

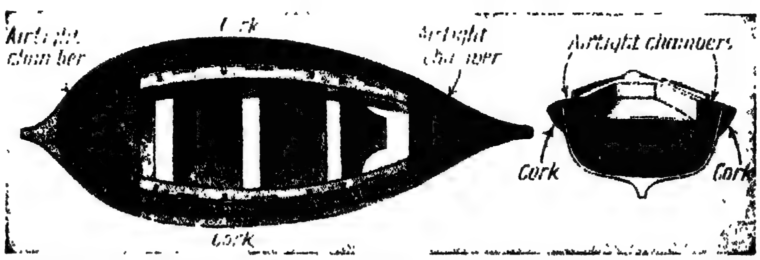
bucket of water drawn from a well. On the water a piece of broken wooden bowl was floating, and Wouldhave absent-mindedly played with this fragment. To his surprise, whenever he turned it over it always righted itself, and it came to him in a flash that here was the principle he had been searching for.

He made a boat more or less in the form of the fragment of broken bowl, and it was a great success. The shape was practically that of a quarter of a coconut shell split from end to end.

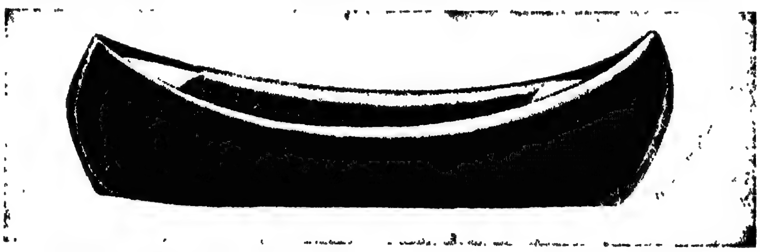
The third Englishman to whom we owe the lifeboat, Henry Greathead, was also a South Shields man, and he was lucky, for while he contributed little to the design, but merely carried out the instructions of others, he was granted £1,200 by the Parliament, a gold medal and fifty guineas by the Society of Arts, and a hundred guineas by Trinity House and Lloyds, together with other gifts.

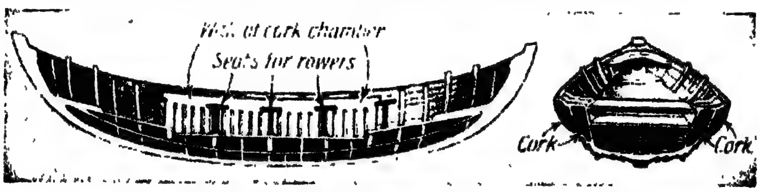
Greathead was a boat-builder by trade, and he actually built many lifeboats. The very first boat actually to be built as a lifeboat was launched in 1789 by Greathead, and cost £76 9s. 8d. Nowadays a motor lifeboat may cost as much as £60,000.

The Royal National Lifeboat Institution was founded in 1824 consequent upon an appeal by Sir William Hillary, of Dunmow, Essex. While living at Douglas in the Isle of Man, Hillary had been shocked by the many terrible wrecks he had seen on the coast and suggested that something should be done to save life at sea. At that time there were 39 lifeboats round the coast of Britain, all provided by local charity and many of them ill-equipped, badly maintained, and manned by untrained crews.



The first lifeboat designed by Lionel Lukin, a London coachbuilder, in 1786


William Wouldhave's model of the very first self-righting lifeboat

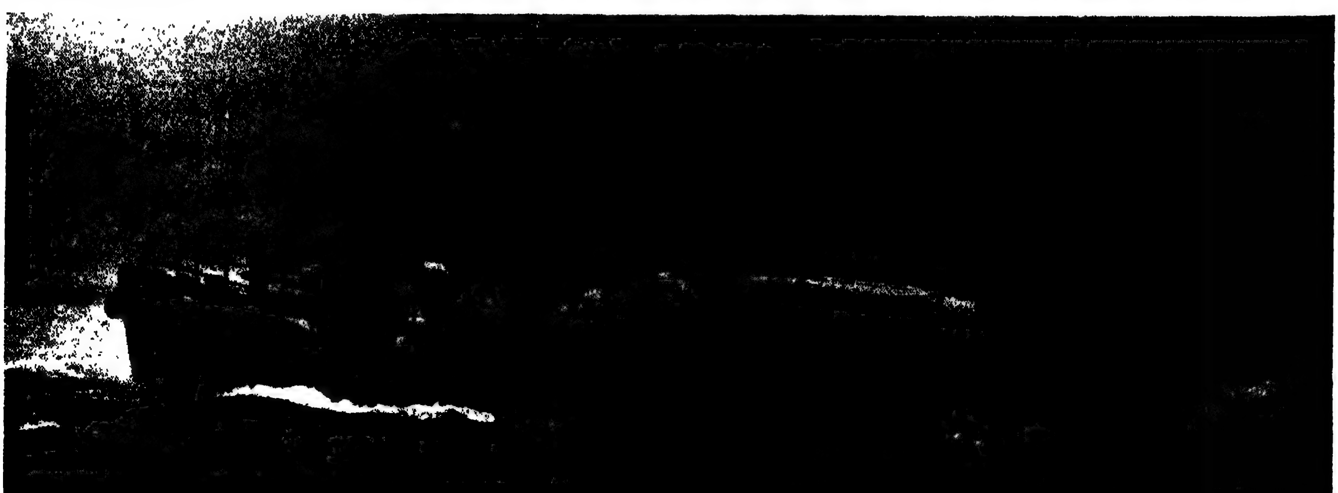


Henry Greathead's first lifeboat, which cost £76 9s. 8d

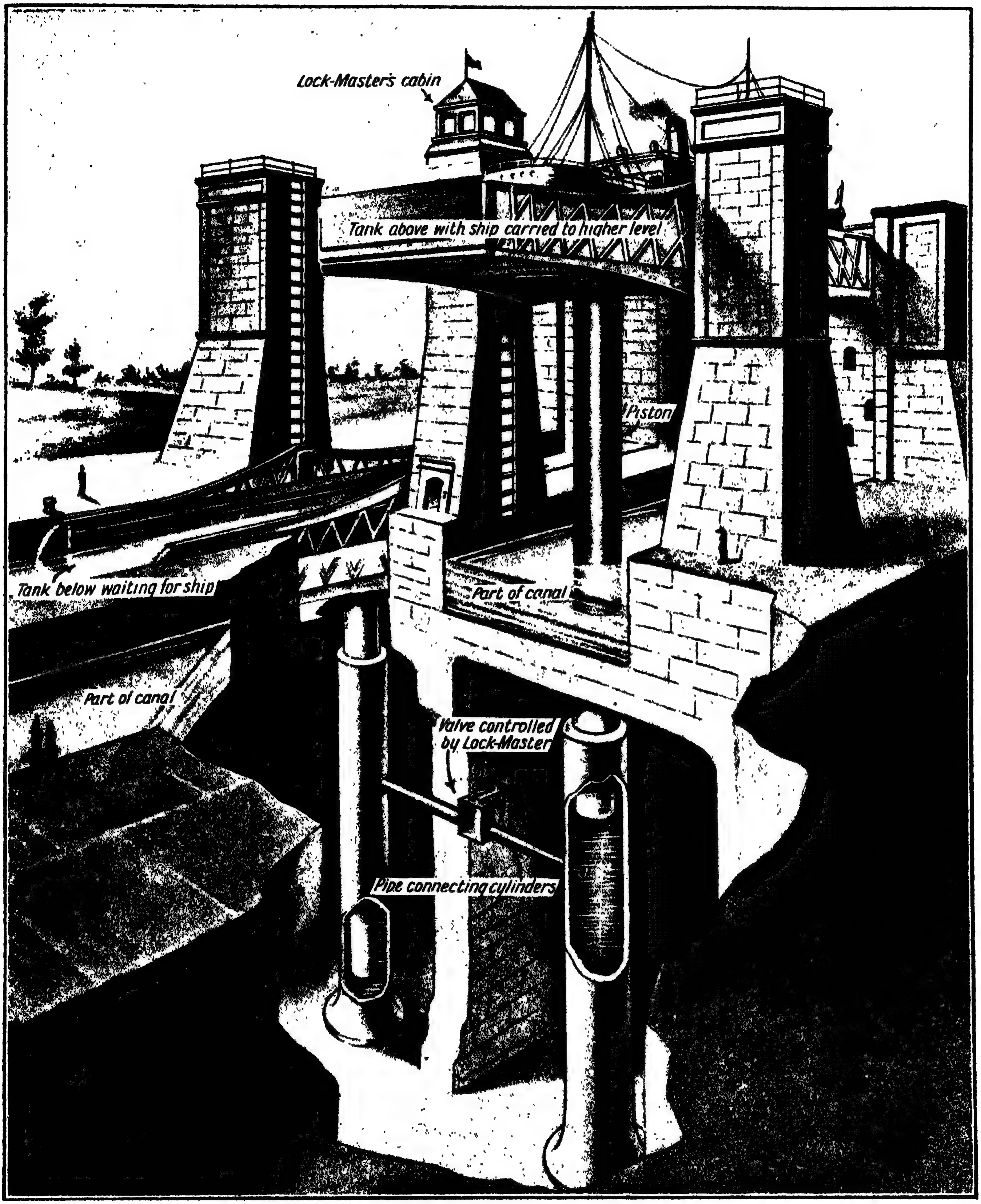
Supported entirely by public subscriptions and contributions from shipowners, the Royal National Lifeboat Institution became responsible for building, manning and maintaining all civil lifeboats operating from the coast of Britain. There is now a fleet of 154 boats, all but one of which are motor-driven, so stationed that wherever a ship is in distress a lifeboat can reach it within an hour or so. Lifeboat crews and shore staff number about 2,000, and of the crews all but the motor-mechanics are unpaid volunteers. Crews are, however, rewarded for every occasion on which they put to sea; officers receive pensions when they retire, and dependents of a lifeboatman who loses his life on duty are pensioned as if the man had been a sailor, soldier or airman killed in action. The Institution also awards gold, silver and bronze medals to lifeboatmen displaying gallantry at sea. Since its foundation in 1824, the Institution has saved nearly 80,000 lives from the sea.

Although primarily intended for helping ships in distress, the Institution works in close co-operation with the Air Sea Rescue Service of the Royal Air Force.

Some 20 foreign countries now maintain lifeboat services, organised on the lines of the Royal National Lifeboat Institution, but mostly operated by the governments concerned.

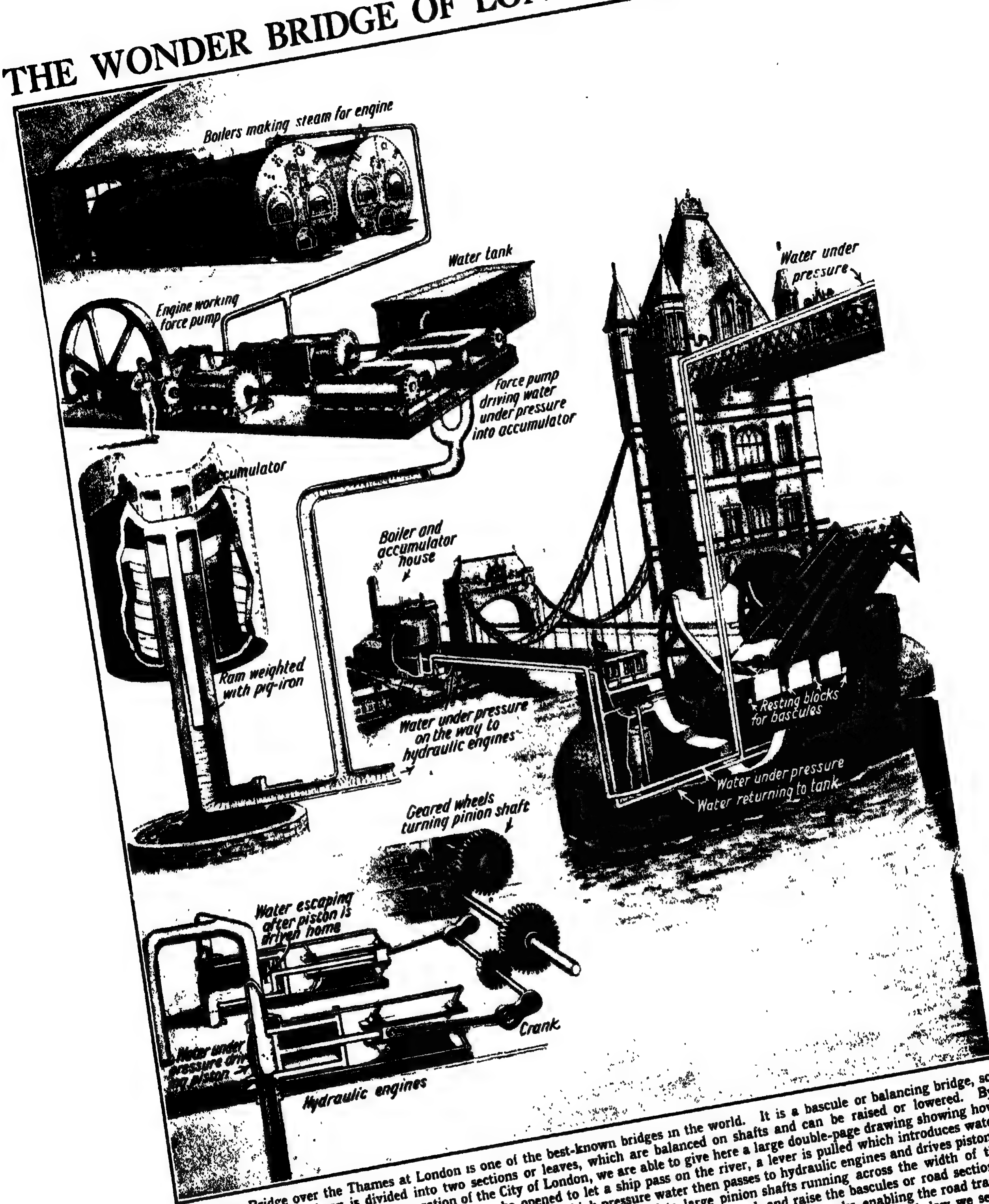

This photograph shows the lifeboat North Foreland at sea off her station at Margate, Kent. Built by the R.N.L.I. in 1951, she is 46 feet 9 inches long and 12 feet 9 inches wide, and weighs 22½ tons. Her two 40 h.p. diesel engines drive twin screws to give a maximum speed of 8½ knots and she carries enough fuel to travel 230 miles at full speed. The hull is divided into nine water-tight compartments, and each engine is itself water-tight and can continue running if the engine room is flooded. Equipment includes radio-telephony, searchlight, and an oil spray for making smoother the sea round a wreck. There is a crew of 8 and accommodation for 95 passengers

HOW A LIFT RAISES A SHIP 65 FEET



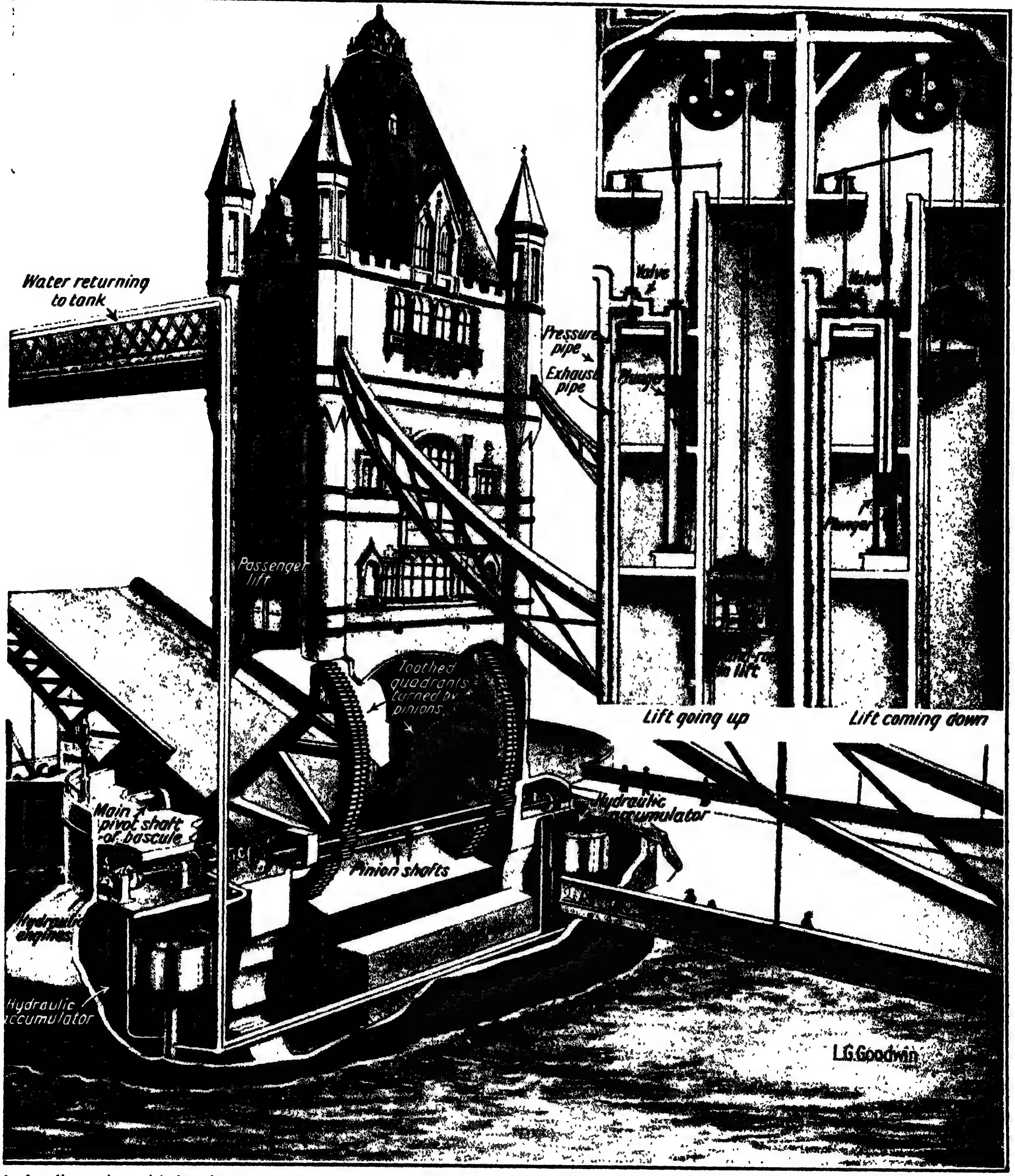
This apparatus at Peterborough, Ontario, is known as a lift lock, and takes the place of the ordinary type of canal lock, because here the difference in water level is very great. The ship at the lower level enters a big tank, and then, by the pulling of a lever, the tank is raised 65 feet by means of plungers working in cylinders of water at high pressure. It is on the same principle as the hydraulic lifts of the Tower Bridge shown on page 365, and the hydraulic press explained on page 184. As soon as the tank is raised to its full height a watertight door is opened and the ship steams out into the canal at the higher level. For bringing ships down the process is reversed

THE WONDER BRIDGE OF LONDON AND HOW



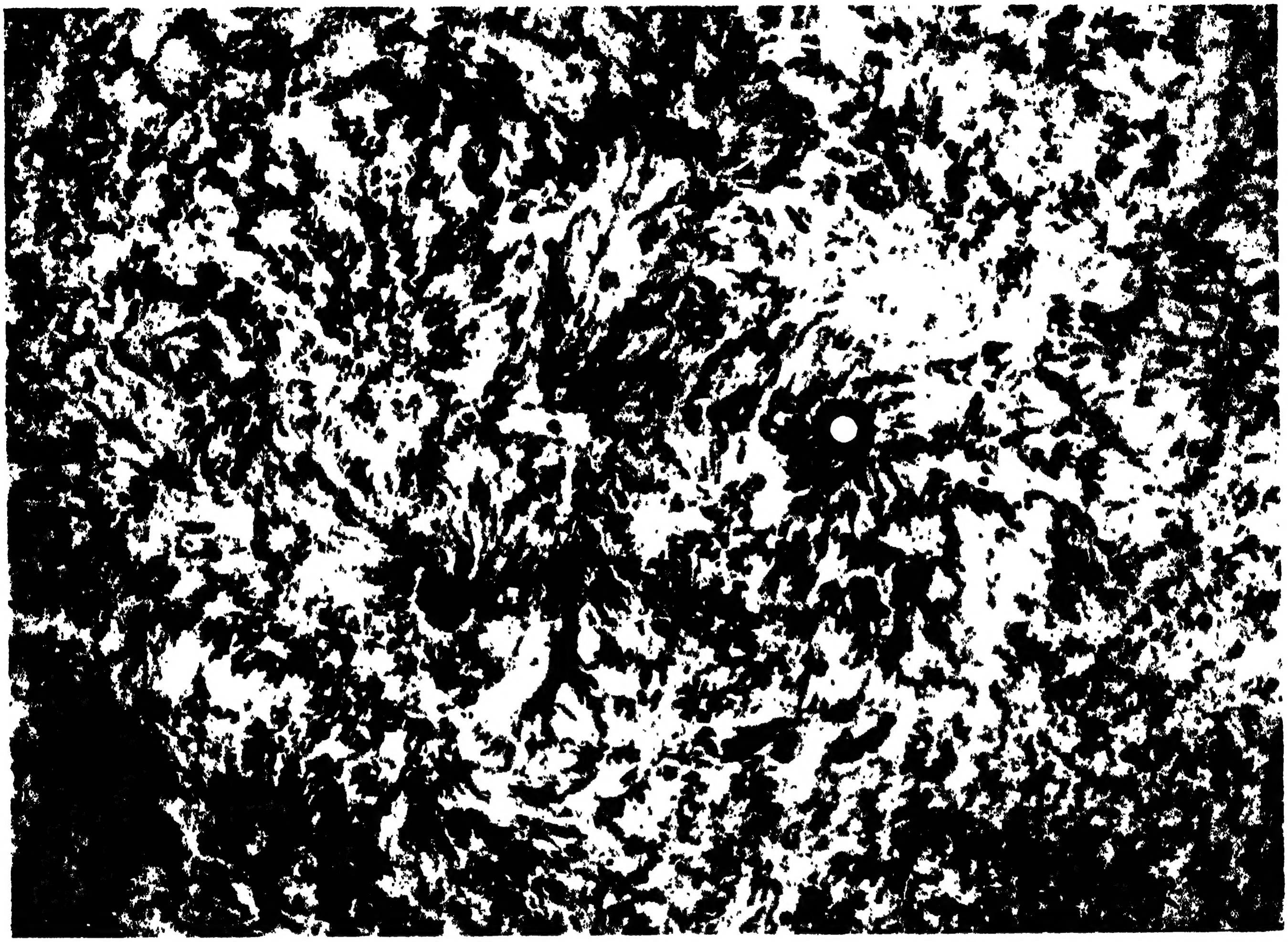
The Tower Bridge over the Thames at London is one of the best-known bridges in the world. It is a bascule or balancing bridge, so called because its roadway is divided into two sections or leaves, which are balanced on shafts and can be raised or lowered. By courtesy of the Town Clerk and Corporation of the City of London, we are able to give here a large double-page drawing showing how this famous bridge works. When the bridge is to be opened to let a ship pass on the river, a lever is pulled which introduces water under pressure into a series of hydraulic accumulators. The high pressure water then passes to hydraulic engines and drives pistons, which turn cranks and move a series of geared wheels. These are attached to large pinion shafts running across the width of the bridge. Geared wheels on these shafts engage with large toothed quadrants, which are turned, and raise the bascules or road sections. As soon as the ship has passed the reverse process takes place, and the bascules come down and rest on blocks, enabling the road traffic to be resumed. The pictures on the left show the pumps driving water under pressure into an accumulator, and below we see a

IT IS WORKED BY THE MOVING OF A LEVER

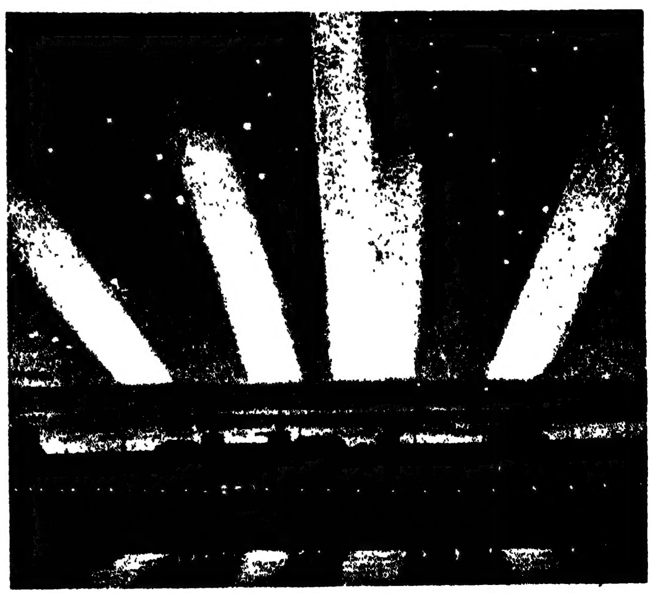


hydraulic engine with its pistons working alternately and turning the cranks. The water under pressure returns to its original tank after use, passing in pipes up the towers and across the footbridge at the top. It is used over and over again in raising and lowering the bascules. On the right are shown the hydraulic lifts, which are now rarely used, as the bascules are raised and lowered so rapidly that passengers wait rather than go up and across the footbridge. Here the man in the lift pulls a hand rope, which opens a valve and allows water, under pressure, to drive down a plunger. A rope attached to this passes over a pulley, raising the lift, and a counter-balancing weight is attached to a rope passing over another pulley. When the lift is to come down the hand rope closes the valve and the pressure pipe, and the lift descends by its own weight, emptying the water through an exhaust pipe. Each of the two great leaves or bascules of the Tower Bridge is 160 feet in length, and weighs, with the counterpoise of lead and iron, 1,200 tons. The bar or trunnion on which each bascule turns is 21 inches in diameter. The hydraulic pressure for turning these great masses is 850 pounds to the square inch

A FIERY TORNADO ON THE SUN'S SURFACE



This wonderful photograph taken by Mr G. E. Hale shows a sun-spot on the Sun's surface. A sun-spot is a gigantic tornado on the Sun in which there are vortices or whirling masses of hot metallic gases thrown up. Two of these vortices can be seen here, and on one the white dot represents the Earth drawn to the same proportion. Many of these sun-spots are 40,000 miles in diameter, and one of the largest ever known, which occurred in 1905, was big enough to swallow up forty of our worlds. Sun-spots appear darker than the surrounding surface because the gases as they rise become partially cooled and are therefore less bright than the adjacent parts

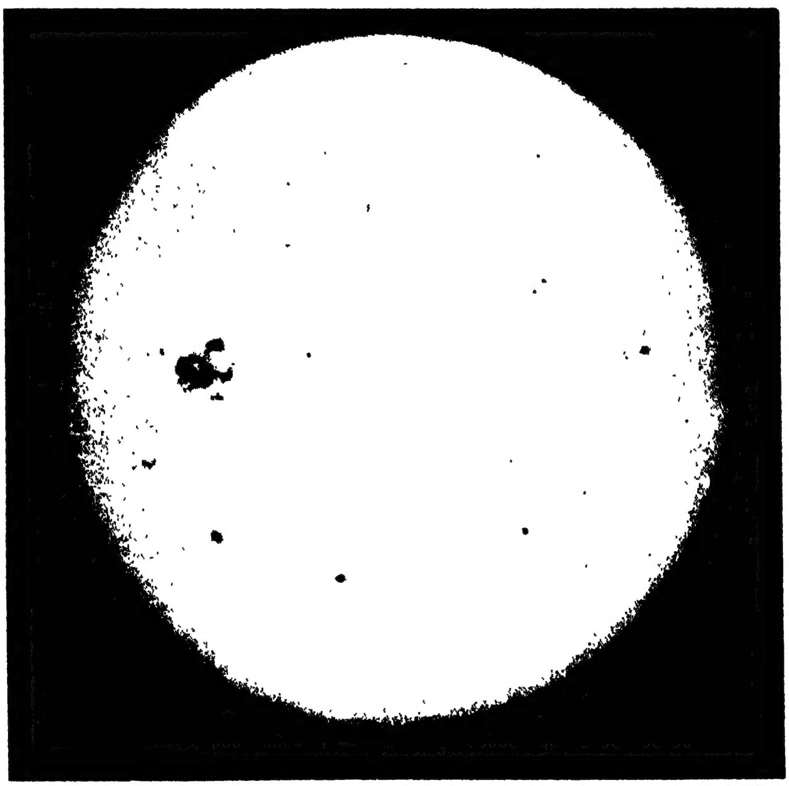


Sun-spots are sources of great magnetic activity. It is believed that masses of electrons are thrown out from the sun-spots and that these, when they reach the Earth, cause magnetic disturbances, as indicated by unusual movements of the compass needle, and displays of the Aurora. Here, on the left, we see a remarkable Aurora witnessed in the Arctic, and on the right a display seen at Paris in 1869

A TITANIC TEMPEST ON THE SUN

From time to time dark spots appear on the Sun's disc. When seen through a small telescope they seem to be merely black patches. It is only in recent times that their true nature has become known, and they are now believed to be great whirling tornadoes of fire. Although they look so small to us, they are all big enough to swallow up the Earth many times over. Here we read something about these titanic tempests

For hundreds of years men have studied the Sun, that brilliant glowing disc in the heavens which gives us light and heat and food. But until the days of the telescope they did not find out a great deal about its nature. Nevertheless, with the naked eye they noticed that certain dark spots occurred from time to time on the Sun's face, though what these could be no one could say. When the telescope became available it was possible to study these dark markings much more closely, and it was soon noticed that when a mark appeared on the solar disc it moved slowly across the Sun's face from east to west, the complete passage from the eastern extremity of the disc to the western side taking about a fortnight.



A photograph of the Sun, showing a remarkable number of sun-spots, including a large group of several spots together more than 70,000 miles in diameter

Galileo's Discovery

It was supposed at first that these sun-spots must be due to the passing of Mercury or some smaller planet across the Sun's face. But that great man Galileo showed that the spots were part of the Sun itself. This being so it was clear that the Sun was a body rotating on its axis in about twenty-six days. It was the sun-spots that gave this information.

Not much more was discovered till well into the nineteenth century, when it was found by patient examination over many years that the number of spots which had seemed to vary by chance from year to year really occurred in a more or less regular succession over periods of eleven years. Sometimes the Sun's disc is quite free of spots, while at other times there are many. From a minimum of spots the number increases for about four and a half years when the maximum is reached, and then the number decreases for six and a half years till the minimum is reached again, after which there is another cycle of a similar period.

Another discovery was that the variations in the number of sun-spots corresponded with the number of auroras seen in our skies and with the fluctuations of the magnetic needle. When there was a maximum of sun-spots on the solar disc auroras were particularly numerous and brilliant, and disturbances of the magnetic needle were extensive. It was found, however, that it is not always the largest sun-spots that cause the greatest magnetic disturbances on the Earth. We read more about the influence of sun-spots in this way in another part of this book, but here we must inquire what a sun-spot really is.

As seen through the telescope it consists of a dark central part surrounded by a lighter fringe. But while, to the observer, the sun-spot seems dark it is not really so, but only dark in comparison with the greater brilliance of the other parts of the Sun's disc. Scientific instruments have shown that the dark part of the spot radiates about one hundredth of the light given out by the more brilliant areas of the Sun's surface. This means that the blackest portion of a sun-spot is considerably brighter than the very dazzling light of an acetylene lamp.

Sun-spots generally occur in groups, and only a few years ago they were supposed to be cavities in the surface of the Sun. The reason for this belief was that as the spots passed across the disc and neared the edge they appeared as if they were saucer-shaped hollows with sloping sides. All spots, however, did not give this appearance, and the theory has been modified. It is now believed that the spots are at various levels, some really forming cavities in the Sun's surface, while others are raised up.

The Birth of a Sun-Spot

Some sun-spots are comparatively small, the dark part not exceeding about 500 miles in width, but in some the dark part is 50,000 miles across and the less dark fringe brings the total diameter up to about 150,000 miles, or nearly twenty times the diameter of the Earth; in fact, on a large sun-spot the Earth would appear merely as a tiny dot. The comparative sizes of the Earth and a big sun-spot are shown in the picture on page 366. Generally round the dark part of a sun-spot, which is known as the umbra (a Latin word meaning shade) there are many small black spots which are often referred to as "Dawes' holes," after the name of their first discoverer.

The development of a sun-spot is very interesting. In the neighbourhood of the spot there are bright streaks and patches which are known as faculae, a Latin word meaning "little torches." Generally the faculae appear first, then a number of small dark points which increase in size and join

up. Gradually the filaments of the fringe or penumbra, as it is called, form round the dark part or umbra. The whole process may take only a few hours or it may take several days.

Meanwhile other spots have generally been forming, and the irregular group now stretches out east and west, and generally two of the spots are larger than the others, one being in front of the group and the other forming a rear-guard, as it were. Often the rear spot is larger than the leader. Then as time goes on the small spots often disappear altogether, and the large rear spot settles down and for some time shows little change. Frequently the leading spot disappears with the small ones. At times a large spot may divide up into a number of small ones with bright links or bridges joining them together.

One interesting thing that has been revealed by the sun-spots is that the whole of the Sun's surface does not rotate about its axis in the same period. The Equator takes about 25 days to make a complete circuit, whereas at latitude 30, which would correspond on the Earth to about the Canary Islands and Florida, the period of rotation is 27 days; at latitude 45, corresponding to France and Nova

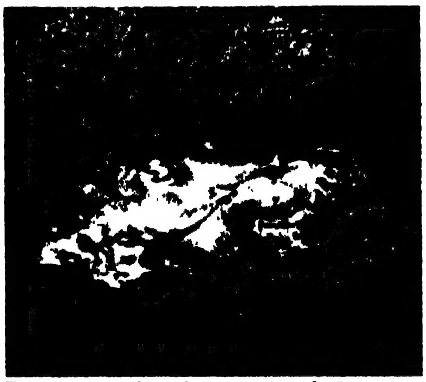
Sun-spots, showing the curious mottled appearance of the Sun's surface all round. These granulations are sometimes called "rice grains" and sometimes "willow leaves" by astronomical observers

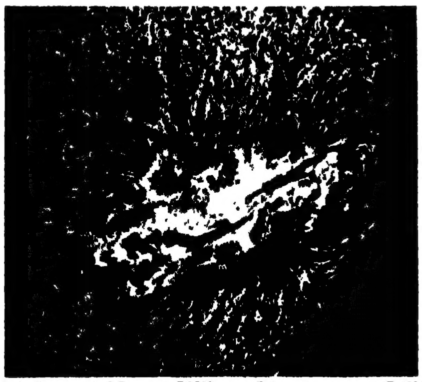
menon, and so it is. In a moment or two it may destroy a town, but it is as nothing compared with these titanic fiery tempests on the Sun. They rage over an area often 150,000 square miles in extent, and they reach a height of over half a million miles. In such a fiery storm the Earth would be destroyed in a single moment.

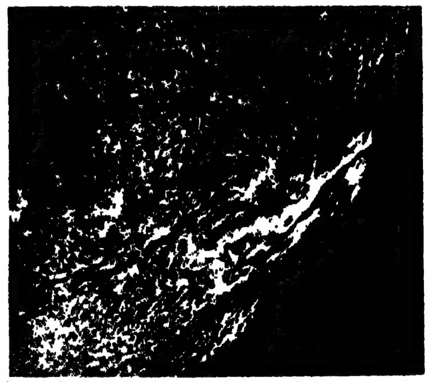
For some reason the gases in the Sun's atmosphere expand suddenly, and as happens always when a gas expands suddenly, its temperature drops. It is this drop in temperature that causes the sun-spot to appear dark in comparison with the rest of the Sun's surface.

Scientists tell us that the temperature of a sun-spot is roughly about 3,000 degrees Centigrade, whereas the the temperature of other parts of the Sun's disc is from about 6,000 to 10,000 degrees Centigrade, the latter being the probable heat deep down in the hydrogen atmosphere. But, of course, the temperature in the heart of the Sun itself is much greater still. There we get incredible heat and Sir James Jeans tells us that at the centre of the Sun the temperature is something like 40 million degrees.

The sun-spots are believed to affect the Earth's weather, but if this is really







Three successive photographs of a huge sun-spot taken at Mount Wilson Observatory, California. The changing positions of the sun-spot in these photographs shows that the sun is rotating. In the third photograph the sun-spot has reached the Sun's edge and is about to disappear from sight having travelled across the surface

Scotia on the Earth, the rotation period is 29 days, and that part of the Sun which corresponds to our Polar regions appears to take 35 days to go round completely. This is the same thing as saying that if on the Earth, Panama went round in 24 hours Cairo would go round in 26 hours, Marseilles in 28 hours, and Spitzbergen in 33 hours.

But we still want to know what sun-spots are. At one time it was supposed that they were eruptions, the spots themselves being a kind of crater. Another idea was that the spots were formed not by any action from within the Sun itself, but by cooler matter descending from above, and most probably of meteoric origin.

The idea generally held now by astronomers is that a sun-spot is really a cyclone or tornado of flaming hydrogen. An ordinary photograph taken of the Sun's disc shows it as more or less uniform in colour and the spots stand out as dark blots. But when a photograph is taken with the aid of a delicate instrument known as a spectro-heliograph, it shows the Sun's surface to be very mottled, and we really get a picture of the atmosphere of hydrogen gas which surrounds the Sun.

In such a photograph the sun-spot appears as a huge maelstrom, and a succession of photographs of the same spot makes very clear the vortex motion that is the whirling nature of the spot just as though it were a huge whirlpool of flame. A sun-spot is believed to be due to the sudden expansion of solar gases resulting in a terrific revolving storm in which hydrogen from above is sucked down.

We think of a tornado on the Earth's surface as a terrific phenomenon, so we cannot be sure to what extent our weather is made by the spots. They cannot diminish the heat and light of the Sun as received by the Earth to any very appreciable extent, for when there are most spots they never cover as much as one thousandth part of the solar side.

Of course, all this knowledge about sun-spots has only been found out by the infinite patience of the astronomers exerted over a long course of years. For instance, Professor Schwabe of Dessau found that the number of spots varies from year to year over regular periods of $11\frac{1}{4}$ years, but it took him many years of watching to discover this. It was said of him: "Twelve years he spent to satisfy himself, six more to satisfy, and still thirteen more to convince, mankind, an instance of devoted persistence unsurpassed in the annals of astronomy."